COMBUSTION

Vol. 4, No. 5 NOVEMBER, 1932 25c a copy

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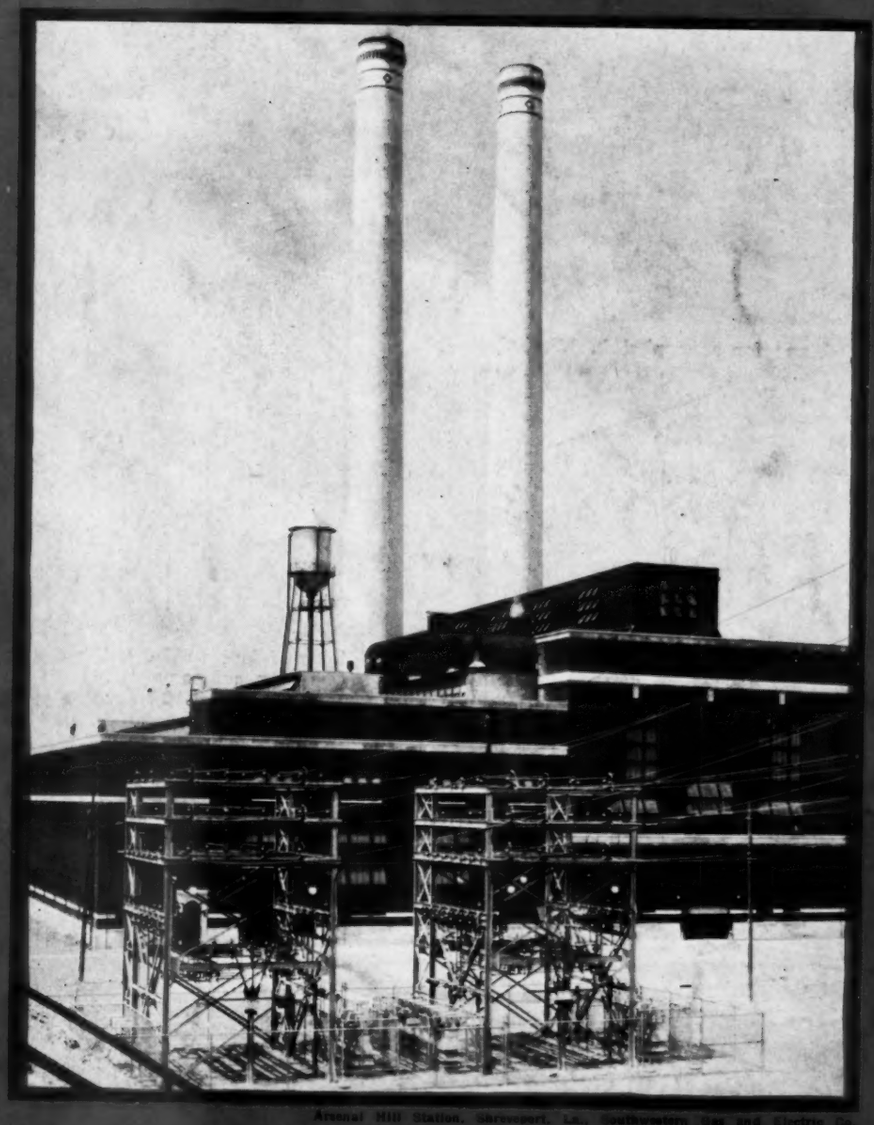


Arsenal Hill Station, Shreveport, La., Southwestern Gas and Electric Co.

Performance of High-Pressure Plant of Ford Motor Company

By W. W. Dulmage

Heat Loss Through Insulated Firebrick

By R. C. Denny

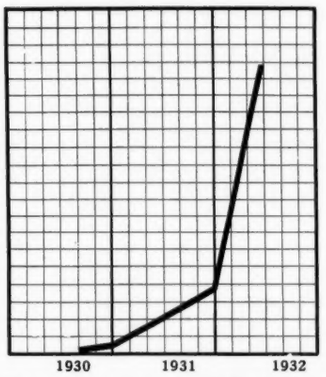
Other Articles in This Issue By

GEORGE RAMSEY • P. B. PLACE • JOSEPH KEENAN • DAVID BROWNLIE

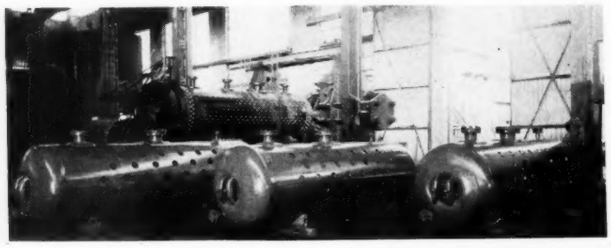
Walsh-Weidner Fusion-Welded Boiler Drums and Pressure Vessels

as recently fabricated by our Chattanooga Shop

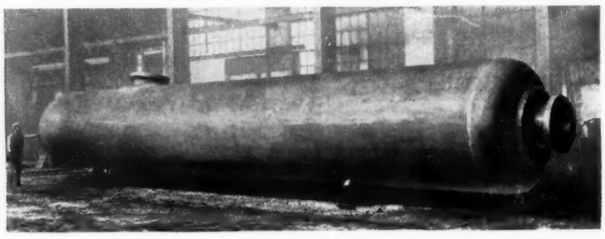
Write for illustrated articles describing the development and practice of fusion-welding as applied to the fabrication of boiler drums and pressure vessels.



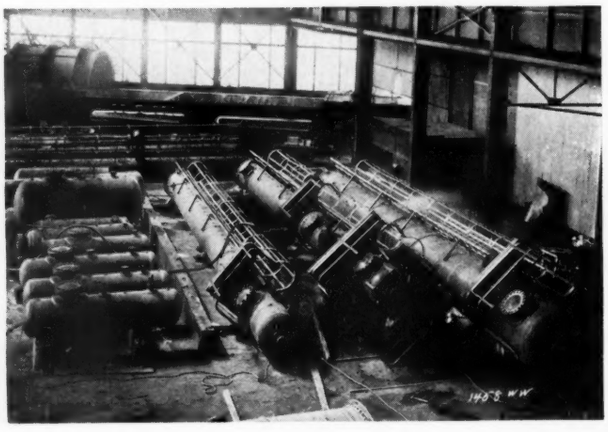
Rate of increase in production of Walsh-Weidner welded drums and pressure vessels from Aug. 1930 to July 1932.



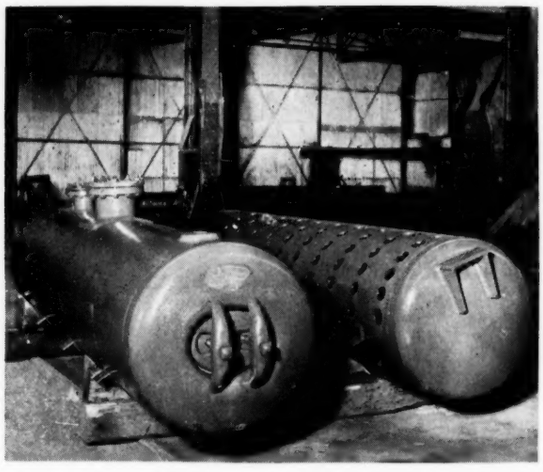
Three welded boiler drums for a hospital in Mississippi—length 14 ft. 3 in., inside diameter 48 in., shell thickness 13/16 in., designed for 250 lb. pressure.



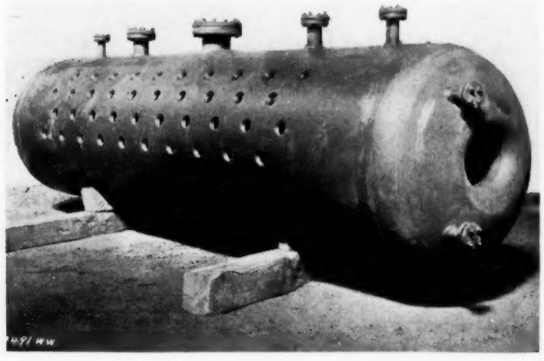
Welded pressure vessel for a large oil company in Kansas —length 46 ft., diameter 78 in., shell thickness 2½ in., weight 107,000 lb.



Fifteen welded pressure vessels ready for shipment to the vapor recovery plant of an oil refinery. In the background can be seen two welded boiler drums in front of the annealing furnace.



Two of four welded boiler drums for a large manufacturing company—length 11 ft. 6 in., inside diameter 36 in., shell thickness ⅝ in., designed for 200 lb. pressure.



Welded boiler drum for a large oil refining company —length 16 ft., diameter 54 in., shell thickness 1-19/32 in., designed for 450 lb. pressure.

COMBUSTION ENGINEERING CORPORATION

200 Madison Avenue **New York**

COMBUSTION

VOLUME FOUR • NUMBER FIVE

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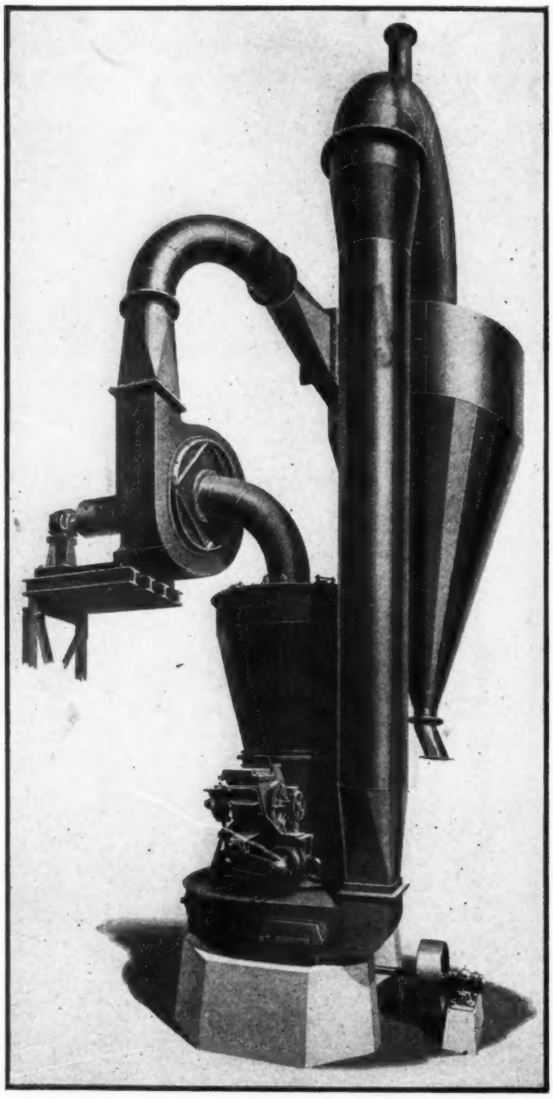
22,700,000 Tons

of coal per year is the rated capacity of Raymond Mills installed in American Plants



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Commentary by Joseph H. Keenan

Heat—The Quest Continued

If we push forward the piston closing the end of a cylinder containing air we may observe a rise in the temperature and the pressure of the air.

If we place a hot stove lid in contact with a vessel of fixed volume containing another sample of air we may observe as before a rise in temperature and pressure.

In both cases energy is added to the air. In both cases we have to do with energy in transition. It is hardly controversial to claim that the energy in transition in the first instance is work, and in the second instance heat. Nor is it controversial to claim that the work of the first instance did not exist as work before the transition or that it ceased to exist as work at the completion of the transition. We do not refer to the work *in* the air after the piston has come to rest. The energy which passed to the fluid as work may now appear as internal energy, it is no longer work.

When we say that the heat of the second example did not exist as heat before the transition or that it ceased to exist at the completion of the transition, we encounter disagreement. We can pick instances from authoritative sources where the term heat is used indiscriminately for internal energy, for enthalpy and even for work. A much revered handbook, despite the contradiction in terms, refers to the integral of Tds in irreversible *adiabatic* processes as heat. A term as accommodating as this one fits well the description of Private James:

> "No characteristic trait had he
> Of any distinctive kind."

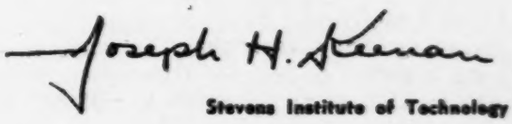
But thermodynamics does not treat heat so unkindly. Its fundamentals clearly imply that heat, like work, is energy in transition; it can exist only during a transition process. To complete its definition we must differentiate it from other kinds of energy in transition.

The first of our two sample operations on air involved a force applied to the air by a moving piston. The moving force, which immediately suggests work, characterizes this example. If we look for some distinguishing characteristic of the second example, we find it in the "hotness" or temperature of the stove lid. We realize that if the gas had been hotter than the stove lid the energy flow would have been reversed. Thus, the energy flow in our heat example depends upon a difference in temperature between the source of the heat and the receiver of the heat, and its direction is downgrade on the temperature scale.

On the strength of this reasoning we might expand our definition of heat to *heat is energy in transition from one substance to a substance at lower temperature by virtue of the temperature difference.*

Our first attempt to define heat* was based on the implications to be found in the fundamental principles of thermodynamics. From a similar basis we might verify this more complete definition.

The first principle makes clear that heat is not energy in storage in a substance. We must look to the second principle to complete the definition. Callendar translates Carnot's statement of the second principle as follows: "The motive power of heat is independent of the agents set at work to realize it; its quantity is fixed solely by the temperatures between which in the limit the transfer of heat takes place". Unless this principle is meaningless, heat and temperature are inseparable companions. We may infer also that heat transfer can occur in only one direction in a temperature gradient; for if we were to assume that heat transfer could occur from a heat source toward either higher or lower temperatures then we could conceive of the working substance in our heat engine being put through the same cycle with the same amount of work production regardless of whether the heat source was at a temperature above or below the maximum temperature of the working substance. The "motive power of heat" would then be independent of the temperature of the heat source and the principle would be contradicted. All generally accepted temperature scales agree in designating the temperature *from* which heat transfers as the higher of any pair of temperatures. If we adopt any one of these scales we find implied in the two principles of thermodynamics the definition we hoped to verify: heat is energy in transition from one substance to a substance at lower temperature by virtue of the temperature difference.



Stevens Institute of Technology

* In October issue.

EDITORIAL

Combustion and Steam Generation —a field of exceptional opportunity

ADMITTING that we may be somewhat prejudiced, we believe there is no branch of engineering today which offers greater opportunity to the individual than that defined by the words "combustion" and "steam generation." This may appear to be an extravagant statement so let's consider the reasons behind it.

We shall start with basic facts. Over 90 per cent of the total power consumed in this country is produced from the heat energy of fuels. Over 60 per cent of this power is produced by steam generated by the combustion of coal. The principal part of the remaining 30 per cent is produced by steam generated by the combustion of oil, gas and other fuels. In addition to this, steam plays a large and vital part in many industrial processes. In fact, it has been estimated that the amount of boiler horsepower used to provide steam for heating and process work in all industrial plants is about equivalent to that used for power production in such plants.

No further illustration is needed to justify the statement that steam is the basic force motivating the machinery of all industry. Viewed from the standpoint of economics, the investment in steam plant equipment in this country, based on some 20,000,000 installed boiler horsepower (this figure is conservatively limited to stationary plants with a minimum of 200-300 boiler horsepower) amounts to approximately two billion dollars. Assuming a 5 per cent annual rate to cover replacements and repairs the average yearly upkeep expenditure amounts to $100,000,000. In addition to this there is the cost of fuel, water and other supplies totalling in the neighborhood of a billion dollars annually.

Now as to the opportunities for the individual in this field. While commercial practice in practically all other well-established branches of engineering has become highly developed and standardized, the modern stage of development in the old arts of combustion and steam generation has only begun within the past ten years. For example, electrical engineering has become a fairly exact science, and there are literally thousands of electrical engineers who are capable of handling the average run of problems incident to the installation of power generation and transmission equipment. On the other hand, the engineer in charge of designing a modern steam plant, small or large, finds himself confronted with a highly complex problem involving many variables. To solve it, he must have a thorough technical background and must also be able to apply much knowledge not to be found in handbooks but procurable only from the school of experience. The proper evaluation of available fuels and selection of equipment best suited to their use, the design of furnaces, proportioning of heating surfaces,—boiler, water-wall, economizer and air preheater—determination of combustion and heat transfer rates and similar calculations, all present problems which relatively, few engineers are qualified to handle.

And development in this field is going on apace. While established procedures and practice may be followed safely up to a certain point, each new installation presents problems peculiar to it and even established practices are subject to frequent and sometimes radical change.

Here then is a field of engineering which offers a real challenge to the energy, ability and ingenuity of the individual who engages in it. And with the rapidly growing appreciation of the economic importance of steam, on the part of those whose operations depend upon it, the engineer who avails himself of the opportunities inherent in the field will find commensurate rewards.

Practicability of High Steam Pressures

SIGNIFICANT of the rapidity of progress in steam generation is the performance record of the Ford high-pressure plant as related in the lead article in this issue. It is only a few years ago that there was much uncertainty as to the commercial practicability of plants operating at such pressures as 1200 to 1400 lb. per sq .in. Today this attitude has entirely disappeared and any uncertainty that may exist has to do with the relative economy and advantages of such pressures as compared with moderately high-pressures and high temperatures.

In more than a year's operation of the Ford high-pressure boilers and turbine, no serious difficulties have been encountered with reheaters or feed pumps, and leakage difficulties have been no greater than those normally experienced with low-pressure steam. Overall results have been excellent. In fact only a few of the most efficient central stations are obtaining comparable results.

In brief, it appears that in so far as design, construction and operating problems are concerned, high-pressure equipment has now been developed to a degree of dependableness comparable to that of low-pressure equipment. Considering the relatively short time that has elapsed since super-pressures were first proposed for commercial use, this is indeed remarkable progress.

Performance of High-Pressure Plant of Ford Motor Company

The Rouge Plant of the Ford Motor Company is certainly one of the most interesting steam power plants in the world. With a maximum steam production of approximately 4,000,000 lb. per hr. it is believed to be the largest industrial power plant. Its two 1200-lb. pressure units, each having a maximum capacity of over 700,000 lb. per hr. are the largest high-pressure boilers in operation today. The operation of these two units since July, 1931 has disclosed no problems or difficulties not normally encountered with average pressure and temperature conditions. Recent tests have indicated performance of an exceptional character with a practically flat efficiency curve from 300,000 to 730,000 lb. of steam per hr. Complete details of these tests are published here for the first time.

By W. W. DULMAGE

Supt. of Power

Ford Motor Company, Detroit, Mich.

IN JULY, 1931, the Ford Motor Company completed the installation of high-pressure equipment for generating 110,000 kw. in No. 1 power house of its Rouge Plant, Dearborn, Michigan. Steam is generated at 1250 lb. pressure and 750 deg. fahr. total temperature from feedwater at 437 deg. fahr. It is expanded in a high-pressure turbine to about 85 lb. pressure, reheated to 550 deg. fahr. by steam at 1215 lb. pressure in reheaters located near the turbine, and expanded in a low-pressure turbine to a condenser vacuum of about 28½ in. The expansion in the two turbines is so proportioned that at full load each turbine generates 55,000 kw. Reheating is done with high-pressure steam at the turbines because the steam generating units are located too far from the turbines to bring the low-pressure steam back to the steam generators for reheating with hot gases. The heat flow cycle is shown in Fig. 1.

Turbine-Generator

The turbine-generator, consisting of a high-pressure unit and a low-pressure unit, has a capacity of 110,000 kw. at 90 per cent power factor. The high-pressure unit is mounted above the low-pressure machine and the same arrangement applies to the separately excited 55,000 kw. generators, which are identically wound for the production of three-phase, 60-cycle current at 13,800 volts. The floor space occupied by the complete unit approximates 0.013 sq. ft. per kw. of rating. The high-pressure turbine is built for 1200-lb steam pressure, 725 deg. fahr. total temperature and the steam exhausts at 70-lb. gage. This steam is reheated to 550 deg. fahr. and passes through the low-pressure turbine, exhausting to the condenser.

The high-pressure turbine has 12 stages, the first stage being a double row Curtis wheel with partial admissions. The low-pressure turbine has 10 stages and is double flow. Both units operate at 1800 r.p.m. and are of approximately equal capacity.

At either side of the unit is a live steam reheater. These reheaters are of a somewhat new design in that each consists of a single nest of straight tubes with a floating head at the bottom. The 1200-lb., 725 deg. fahr. steam enters at the top steam chest, flows down through the tubes and the condensate is removed from the bottom chamber. The exhaust steam from the high-pressure unit enters at the lower end of the reheater shells and circulates radially in and out about concentric baffles until it reaches the top, thus being subjected to almost perfect counter flow with the heating steam. The two reheaters have a total heating surface of 16,300 sq. ft. which is made up of tubes of chrome-vanadium steel 20 ft. 9 in. long, and ¾-in. outside dia.

There are four stages of bleeding to heat the feedwater; the first is from the high-pressure turbine at 320 lb., the second from the cross-over connection at 85 lb. and the third and fourth from the low-pressure turbine at 31.5 and 8.8 lb. absolute. The condensate is taken from the hot well, forced through the air ejectors and then through the generator air coolers and a low-pressure closed heater to a deaerating heater.

There are three booster pumps, each having a capacity of 700,000 lb. of water per hr. and an operating range of 35 to 780 lb. absolute pressure. They take suction from the deaerating heater and force the boiler feedwater through the cross-over and high-pressure heaters to the high-pressure boiler feed pumps. There are three feed pumps,

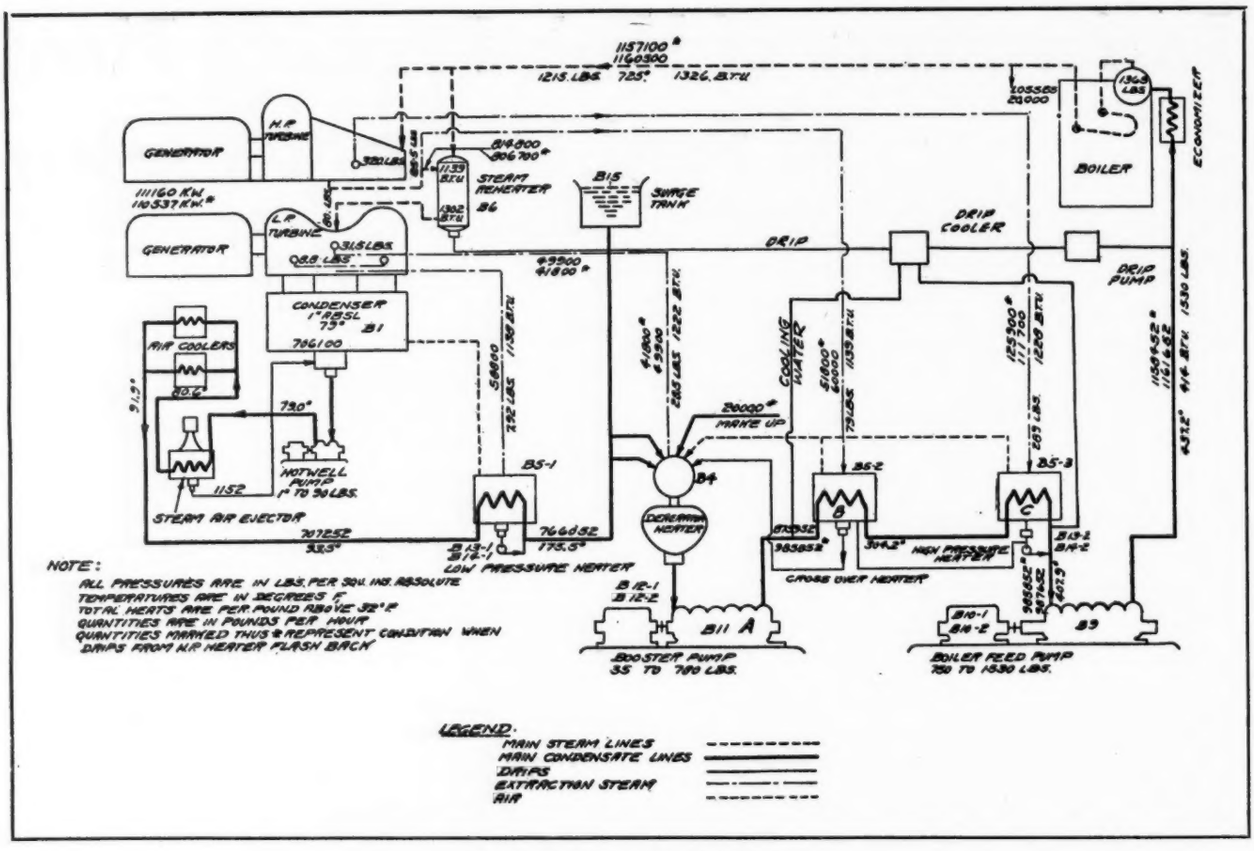


Fig. 1—Diagram of heat balance.

each having a capacity of 800,000 lb. taking their suction at 750 lb. pressure and delivering it to the main boiler feed header at 1615 lb. and at a temperature of approximately 437 deg. fahr.

The condenser is single pass and contains 77,000 sq. ft. of cooling surface. The 12,200 tubes are 28 ft. 3 in. long and ⅞-in. dia. They are rolled at one end and packed at the other. Cooling water is brought through a new tunnel from the Detroit River, by two 80,000 g.p.m. circulating pumps.

The unit was started and brought up to speed July 16, 1931 and has been operating since with only very short shut-downs on some week ends. The average turbine B.t.u. rate (including reheaters) at three-quarter load is 9600 B.t.u. per kw. and the condenser rate is 6100 B.t.u.

So far we have had no trouble with the reheaters. Inspections of the turbine blades have invariably found them free from deposits. There has been no leakage in the condenser. The evaporated make-up runs at the average of 0.07 per cent.

Steam Generating Units

The high-pressure steam is generated by two boiler units which are the largest high-pressure boilers in the world, each having a capacity of 700,000 lb. of steam per hr. Each unit consists of two bent-tube, two-drum boilers, two economizers and two air preheaters placed symmetrically over one water-cooled furnace. The general design is shown in Fig. 2. Each of the two boilers of each unit with its economizer and one half of the water-cooled furnace forms a separate water circulation system. The two boilers discharge steam into a common dry drum from which the steam is distributed to two superheaters one of these being located in the first bank of tubes of each boiler. There are also two separate feedwater controls for each unit. The object of this twin circulation in each unit is to have perfect control of water level

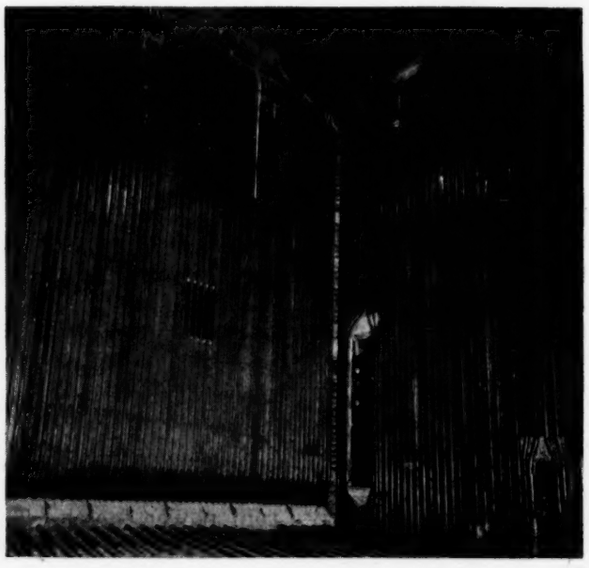


Fig. 2—Interior of water-cooled furnace showing one set of pulverized fuel burners as arranged for corner firing, and, to the left, one gas burner.

in the two steam drums and control of the concentration of solids in the boiler water.

The furnaces are completely water cooled with bare tubes. The water cooling includes the four walls, two arches underneath the lower boiler drums, and a water screen over the bottom of the furnace. The total heating surface exposed to radiant heat is 5234 sq. ft.

The units are fired with pulverized coal and blast furnace gas. The gas burning equipment is of sufficient capacity to generate about 50,000 lb. of steam per hr. Gas is burned when the units are being brought up to pressure and for warming the turbine. Pulverized coal is the principal fuel during normal operation. The coal is fired tangentially by twelve burners, three of which are located in each corner of the furnace 5 to 9 ft. from the bottom. The streams of the mixture of coal and air from the burners are directed tangent to a circle about 8 ft. in dia. in the center of the furnace. This direction of the streams gives rotative motion to the burning mixture which fills the furnace space completely. Coal is supplied by twelve feeders, six under each of two pulverized coal bunkers. The blast furnace gas burners are located near the center of two opposite walls at the same general level as the coal burners.

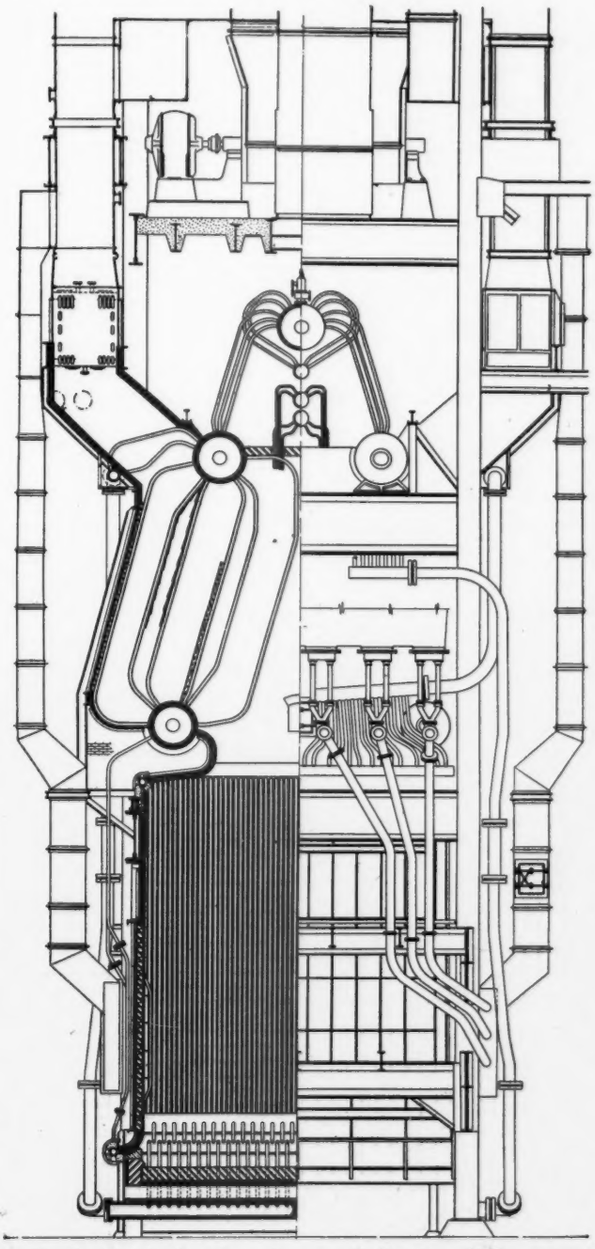


Fig. 3—Sectional elevation of one of the two high-pressure steam generating units.

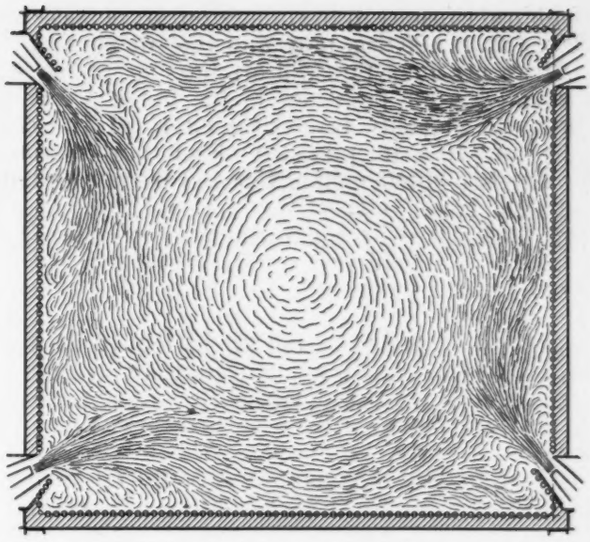


Fig. 4—Diagrammatic plan view of furnace illustrating turbulent action of corner firing.

The furnace is 25 ft. 8 in. by 27 ft. in cross section and 30 ft. high between the water screen and the arches. The total height between the water screen and the apex at the top of the furnace is 52 ft. The total available combustion space is 25,500 cu. ft. At full capacity, 700,000 lb. of steam per hr., the rate of heat liberation is 31,000 B.t.u. per cu. ft. per hr.

The products of combustion are divided into two streams at the top of the furnace, each stream flowing through one half, or one side of the unit. The flow of the gases in each half is controlled by the speed of two induced-draft fans and by a damper system. The duct connection to the induced-draft fans is so designed that either fan can serve both halves of the unit. With only one induced-draft fan in operation, the flow of gas through the two halves of the unit is controlled entirely by the damper system. The induced-draft fans are driven by two-speed induction motors of 800 and 500 hp. running at 514 and 400 r.p.m. respectively. The lower speed is used during normal operation when both fans are running and when the two boiler units are supplying steam to the turbo-generator. In case one induced-draft fan is disabled the other fan can be operated at the higher speed making it possible for the boiler unit, thus crippled to generate 600,000 lb. of steam per hr. The higher speed is used also when only one steam generating unit is in service in which case enough steam can be made on one unit to carry three-quarters of the full load on the steam turbine. The

combined capacity of the induced-draft fans is 420,000 c.f.m. at 400 deg. fahr. and 12½ in. suction.

There are four forced-draft fans supplying air through the air preheater to the burners. Their combined capacity is 200,000 c.f.m. at 100 deg. fahr. and 10¼ in. pressure. Each fan is driven by one two-speed motor, 150 and 60 hp. at 1200 and 900 r.p.m. respectively. Regulation of air flow is obtained by a damper system. Two fans operated at the higher speed deliver a sufficient volume of air to generate 500,000 lb. of steam per hr.

The ash is removed from the bottom of the furnace by two cast-iron conveyors with water-cooled shafts. It is dropped into two crushers from which it is conveyed by a pneumatic system into a car loading bin. A similar ash handling system has been used at this plant on four large low-pressure units for several years with entire satisfaction. This ash system is working satisfactorily on the high-pressure units.

Each of the two high-pressure steam generating units has been designed to operate at the following efficiencies—

87 per cent when producing 500,000 lb. of steam per hr.
86 per cent when producing 650,000 lb. of steam per hr.
85.5 per cent when producing 700,000 lb. of steam per hr.

Table 1 gives a summary of the principal dimensions and data.

Table 1

Principal Dimensions of Steam Generating Units

Heat absorbing surfaces per unit	
Boiler	32,040 sq. ft.
Furnace	5,234 sq. ft.
Total water heating surface	37,274 sq. ft.
Economizer	14,000 sq. ft.
Air preheater	64,800 sq. ft.
Superheater	11,475 sq. ft.
Total heat absorbing surface	127,549 sq. ft.
Furnace	
Cross section	27 ft. by 25 ft. 8 in.
Height—water screen to arches	30 ft.
Total height—water screen to apex of furnace	52 ft.
Effective combustion space	25,480 cu. ft.
Number of coal burners	12
Number of gas burners	2

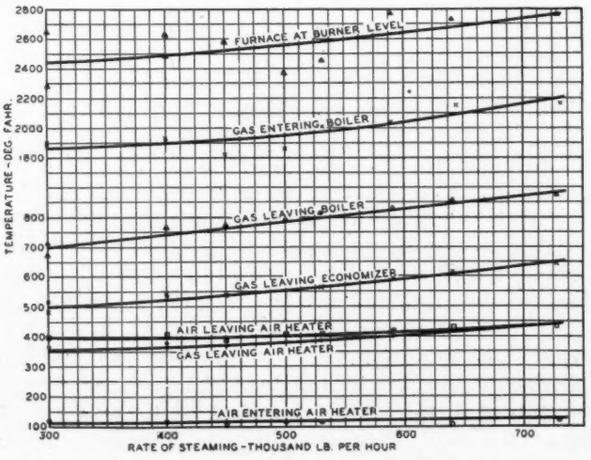

FURNACE AT BURNER LEVEL
GAS ENTERING BOILER
GAS LEAVING BOILER
GAS LEAVING ECONOMIZER
AIR LEAVING AIR HEATER
GAS LEAVING AIR HEATER
AIR ENTERING AIR HEATER
TEMPERATURE - DEG. FAHR.
RATE OF STEAMING - THOUSAND LB. PER HOUR

Fig. 5—Air and gas temperatures.

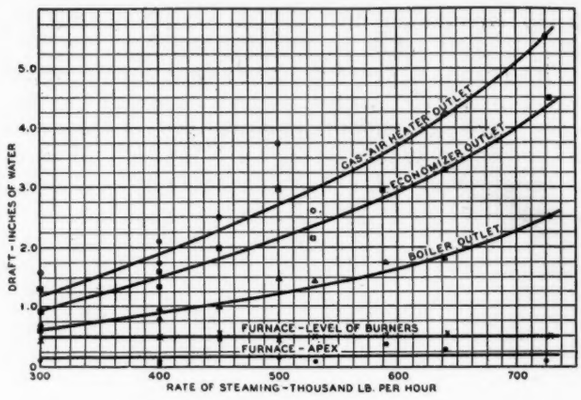

GAS-AIR HEATER OUTLET
ECONOMIZER OUTLET
BOILER OUTLET
FURNACE - LEVEL OF BURNERS
FURNACE - APEX
DRAFT - INCHES OF WATER
RATE OF STEAMING - THOUSAND LB. PER HOUR

Fig. 6—Draft loss through unit.

Operation of Steam Generating Units

The steam generating units were put in operation in July, 1931. No serious difficulty was experienced at that time or subsequently. At first there was some moisture carried over with the steam due to false indication of water level in the steam drums. The water level in the drums was several inches higher than indicated by the water glass. The water columns were, therefore, lowered so that the middle of the water glass was 6 in. below the center of the steam drum. With the water level held in the middle of the water glass, dry steam is obtained even at an evaporation of 750,000 lb. per hr.

So far there has been no more trouble from leakage than would be normally experienced in a low-pressure plant. Leakage is entirely a matter of a proper design and assembly of the joints.

Feedwater Treatment

Feedwater is all condensate. To obtain the best operating conditions the boiler water concentrations are held within close limits as follows:

(a) Total solids not exceeding 400 p.p.m.
(b) Caustic content, calculated as (OH) held between 10 and 20 p.p.m.
(c) Phosphate content, calculated as (PO_4) maintained at approximately 60 p.p.m.
(d) Oxygen content of the feedwater held below 0.025 cubic centimeter per liter.

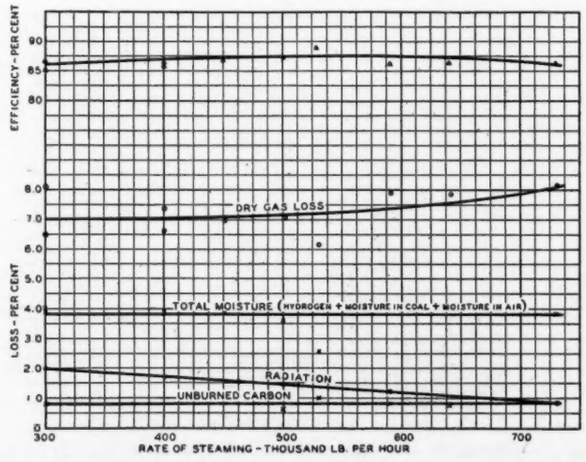

EFFICIENCY - PER CENT
DRY GAS LOSS
TOTAL MOISTURE (HYDROGEN + MOISTURE IN COAL + MOISTURE IN AIR)
RADIATION
UNBURNED CARBON
LOSS - PER CENT
RATE OF STEAMING - THOUSAND LB. PER HOUR

Fig. 7—Performance as determined by heat balance.

Table 2

DATA OF TESTS

Test number	1	2	3	4	5	6	7	8	9	10
Actual evaporation, 1000 lb. per hour	300	300	400	400	450	500	530	590	640	730
Heat per lb. of steam, B.t.u.	976	947	972	959	988	967	985	961	960	974
Proximate analysis of coal										
Volatile matter, per cent	32.5	32.5	32.5	32.5	30.1	26.6	26.8	30.9	30.9	29.4
Fixed carbon, per cent	58.5	58.5	58.5	58.5	60.2	66.6	65.3	60.8	60.8	62.9
Ash, per cent	6.6	6.6	6.6	6.6	7.0	5.0	7.8	7.2	7.2	6.2
Moisture, per cent	2.4	2.4	2.4	2.4	2.7	1.8	1.6	1.1	1.1	1.5
Heat value, B.t.u.	13850	13850	13850	13850	13825	14425	14350	14010	14010	14280
Ultimate analysis—as received										
Carbon, per cent	76.7	76.7	76.7	76.7	75.1	77.8	73.7	76.2	76.2	76.5
Hydrogen, exclusive moisture, per cent	4.81	4.81	4.81	4.81	4.67	4.63	3.21	4.73	4.73	4.73
Sulphur, per cent	.55	.55	.55	.55	.49	.54	.62	.54	.54	.57
Flue Dust										
Combustible in flue dust, per cent	13.8	13.8	13.8	13.8	13.2	14.7	14.2	12.5	12.5	14.7
Carbon burned per lb. of fuel	75.8	75.8	75.8	75.8	74.3	77.1	72.7	75.4	75.4	75.6
Flue Gas Analysis										
Boiler outlet—CO_2	11.4	15.7	12.9	15.1	13.9	13.4	14.7	13.6	14.3	13.7
O_2	8.2	3.5	6.6	4.1	5.0	5.4	4.0	5.2	4.9	5.8
Air heater outlet—CO_2	10.4	12.8	12.3	13.3	12.5	12.8	14.2	12.6	13.1	13.1
O_2	8.1	5.5	6.6	5.7	6.7	6.2	4.2	6.4	6.0	5.7
Products of Combustion per lb. fuel (as received)										
Weight of dry gases per lb. of fuel	18.2	15.0	15.5	14.4	15.1	15.2	13.1	15.1	14.6	14.6
Water vapor from hydrogen	.43	.43	.43	.43	.42	.42	.29	.43	.43	.43
Moisture in coal	.024	.024	.024	.024	.027	.018	.016	.011	.011	.015
Temperatures—deg. fahr.										
Furnace, burner level	2280	2650	2490	2625	2500	2360	2450	2780	2730	2775
Gases entering boiler	1880	1900	1905	1925	1820	1860	2010	2030	2150	2160
Gases leaving boiler	714	675	765	746	771	792	815	825	852	877
Gases leaving economizer	519	487	545	534	537	560	567	598	617	640
Gases leaving air heater	367	361	378	368	369	380	388	402	413	432
Air entering air heater	122	122	116	116	104	111	113	98	99	112
Air leaving air heater	398	400	407	405	383	407	410	413	426	432
Primary air	243	246	244	245	221	268	269	271	278	250
Water to economizer	373	375	375	379	362	375	360	385	386	386
Water from economizer	443	425	441	441	431	439	428	453	453	458
Superheater steam	720	685	718	707	721	710	712	715	716	737
Pressures—lb. per sq. in. gage										
Boiler steam drum	1245	1251	1265	1256	1260	1257	1255	1245	1277	1290
Steam leaving superheater	1233	1234	1240	1230	1225	1234	1225	1209	1233	1240
Feed water	1513	1465	1481	1488	1625	1532	1537	1516	1510	1495
Air pressures—in. of water										
Air heater inlet	3.7	2.1	3.3	2.8	2.2	4.10	4.05	5.0	5.8	8.05
Secondary air	2.6	1.0	1.8	1.8	1.4	2.40	2.56	2.45	2.9	3.9
Primary air	7.35	6.8	6.4	6.4	6.0	7.10	6.90	7.10	7.8	8.8
Draft—in. of water										
Furnace-level of burners	.48	.48	.50	.48	.55	.47	.50	.56	.53	.50
Furnace apex	.11	.13	.08	.10	.5	.15	.10	.40	.30	.10
Boiler outlet	.70	.50	.95	.77	1.0	1.50	1.45	1.75	1.80	2.50
Economizer outlet	1.30	.60	1.60	1.35	2.00	3.00	2.15	2.95	3.30	4.50
Air heater outlet	1.60	.90	2.10	1.72	2.50	3.75	2.60	3.68	4.25	5.57
Heat Balance—per cent										
Losses										
Dry gas	8.10	6.51	7.37	6.60	7.00	7.07	6.13	7.86	7.82	8.12
Water vapor from hydrogen	3.57	3.55	3.60	3.58	3.52	3.39	2.35	3.60	3.61	3.58
Moisture in coal	0.20	0.20	0.20	0.20	0.22	.14	.13	.10	.10	.12
Moisture in air	.15	.14	.12	.12	.11	.10	.11	.10	.10	.12
Combustible in flue dust	.84	.84	.84	.84	.86	.67	.99	.82	.72	.83
Radiation	2.00	2.00	1.75	1.75	1.60	1.45	1.35	1.20	1.05	0.80
Total losses	14.86	13.24	13.88	13.09	13.31	12.82	11.06	13.68	13.40	13.57
Efficiency (by difference)	85.14	86.76	86.12	86.91	86.69	87.18	88.94	86.32	86.60	86.43

Due to the low alkalinity maintained and drums being of all forged construction with no outside caulking, it is not considered necessary to maintain the carbonate-sulphate ratio as recommended by the A.S.M.E. boiler code. Maintenance of low total solids and low caustic content is required to hold carry-over at a minimum. Low caustic content is especially desirable as this chemical tends to increase carry-over and cements other solids on the turbine blading. Maintenance of caustic content as prescribed above is necessary to prevent corrosion. Oxygen content of the feedwater must be held at very low levels. This is accomplished through use of a deaerating heater. Hagan Phosphate, an alkali reducing salt, is used as treating chemical, small doses being given as demanded. Treatment is pumped to the suction of booster pump, thus having immediate access to the boilers as required. Tests to determine necessary treatment and blow-down are made twice daily as a rule. To prevent corrosion to compound tanks and piping a 0.03 per cent sodium chromate solution is used in mixing tanks.

Maintenance of the above conditions, without excessive blow-down, is dependent upon condensate return and distilled water make-up when required.

Our experience with the operation of these high-pressure units has been such that we consider high pressures are entirely practical for central stations as well as for industrial plants. During the few years since the introduction of high steam pressures for the generation of power, high-pressure equipment has been developed to a state of dependableness comparable to that of medium pressure equipment.

The feed pump difficulties which in some of the first higher-pressure installations caused some concern were almost entirely eliminated by improvements in the design. Such difficulties as existed were due more to high temperatures than to high pressures. High steam pressures make possible heating feedwater to higher temperatures by steam extraction from turbine, and this in turn brings new problems in the design and arrangement of the feedwater heating and pumping equipment. The arrangement of this equipment in the Rouge Plant is shown in Fig. 1. So far we have had no trouble with the feed pumps, the packing of which is examined every 30 days.

The pumping of the drip from reheaters presented some difficulties. At first it was decided to pump this drip with the main high-pressure feed pump by discharging the drip into the third stage of this pump. Because of the high temperature of this drip it had a tendency to flash and cause the pump to become steam bound. Therefore temporary equipment was installed to cool the drip until separate pumps could be obtained to discharge the hot drip direct into the boiler feed line. Such pumps are now being installed and results of their operation will be available in a short time.

Performance

The performance of the high-pressure steam generating units, as shown in Table 2 has been slightly better than the guarantees of the designers. The results cover ratings from 300,000 to 730,000 lb. of steam per hr. The efficiency is obtained by heat balance and checks well with daily evaporation and coal consumption. It is practically constant for the entire range of operation. With the tangential, or corner, method of firing the completeness of combustion does not seem to be affected by the rating. The percentage of combustible in the flue dust is low and remains nearly the same for all ratings. The small increase in losses due to rising flue gas temperature is about offset by the decrease in the radiation loss. The draft losses through various parts of the units are affected by excess air as well as by rating. The results are shown graphically in Figs. 5, 6 and 7.

American Standards Association Recommends Standard Value for Conversion of Inches to Millimeters

An American standard value to be used by industry in converting inches to millimeters was recommended by a general conference held under the auspices of the American Standards Association on October 21, following a request of the Ford Motor Company. Representatives of 18 industrial groups having an interest in precise measurements and methods of limit gaging were present. The conference unanimously recommended the conversion factor of one inch equals 25.4 millimeters to become the American Standard value for industrial use, replacing for this purpose both the official ratio 25.40005 and the rounded value 25.4001 given in certain handbooks and tables.

The official British ratio is 25.399978, and the last precise experimentally determined value 25.399956. Thus the British official value is about one part in a million below, and the American official value about two parts in a million above 25.4. British industry, through the British Standards Institution, adopted the value 25.4 for industrial use in 1930. This simple ratio has been advocated by Continental European countries.

The adoption of the conversion ratio 25.4 by American industry will secure world-wide uniformity in conversion practice. For example, an American automobile manufacturer having plants in both metric and inch countries, desiring to have complete interchangeability of parts regardless of the country in which they are made, can use identical blueprints in the respective countries.

The matter is also of importance on account of the fact that the ultimate check on the accuracy of workshop and inspection gages used in manufacturing practice is made by means of highly accurate reference gage blocks held within a tolerance of a few millionths of an inch per inch.

Patents*

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PART IV

Patent Office Procedure (Continued)

The discussion of "claims," begun in the October installment of Mr. Ramsey's series, is continued in this article. The various characteristics and deficiencies which render claims objectionable to the Patent Office or which are likely to lead to rejection are thoroughly described. A number of illustrations are given to show how slight changes in the phrasing of a claim will eliminate causes for rejection. As the author progresses into his subject he makes increasingly apparent the fact that the inventor whose idea is truly original and useful and who is properly guided in his application for patent protection has nothing to fear from the Patent Office but that an idea which is not inherently patentable has little chance of getting beyond the careful and intelligent scrutiny of the Examiner.

Examiners Must Cite Best References

The Examiners in the Patent Office are presumed to take such action relative to pending applications as will result in the issuance of a valid patent. It, therefore, follows that the Examiners apply the precedents established by the Federal Courts when rejecting claims. However, the decision of the Court applies usually to a single patent and voluminous arguments and evidence is before the Court on a particular feature of patent law as applying to that patent. Therefore, the Courts usually go a great deal more fully into the various questions of patent law than does the Examiner. Since all the grounds of rejections which may be relied on by the Patent Office may also be used as defenses in a patent suit, the legal foundation for these rejections will be amplified and more fully explained when we come to consider patent litigation.

The Examiner, as a rule, will merely state his ground of rejection, in a one or two page letter, without going at length or detail into the legal background of the rejection. The Examiner, however, under the Rules of Practice, is required to make a thorough search of the prior art and to cite the best references at his command. The pertinency of the references, if not obvious, must be clearly explained and the alleged anticipated claims specified. Where domestic patents are cited, their dates, numbers, names of the patentees and class of the invention must be stated. Where foreign patents are cited, the same information must be given plus such other data as will enable the applicant to identify the foreign patents specified. Where a printed publication is used as a basis of rejection, the Examiner must cite the title, date, and author of the publication; place of publication; place where a copy of the publication may be found; and the pertinent pages relied upon. The Examiner may reject upon the facts within the personal knowledge of himself or an employee of the Patent Office, in which case, the data shall be specific and must be supported, when called for, by an affidavit. A rejection based on personal knowledge of the Examiner is very rare. Such a rejection based on personal knowledge, is subject to contradiction, or explanation by affidavits on behalf of the applicant.

Designs

Designs cover appearance only. The Patent Office, as a rule, will not permit but one claim in a design patent application. A few design patents have issued with more than one claim and there seems to be no good reason why generic and specific claims should not be allowed in design patents. However, the uniform practice of the Office is to refuse to accept more than one claim. The form of claim which is acceptable to the Patent Office in a design application is "The ornamental design for a ————, as shown." The specification in a design application must be very short and usually comprises merely a brief statement as to the figures of the drawing. Very rarely does a design case require more than one sheet of drawings. Modifications, as a rule, are not allowed in applications for design patents. Each modified design is presumed to be a separate invention. Applications for design patents on a mechanical

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part wherein the part is peculiarly shaped to obtain some mechanical advantage rather than to merely attain a pleasing appearance, will usually be rejected on the ground that the invention resides in the utility and not in ornamentation. Since the scope of a design patent is limited to appearance and may be avoided by change in appearance, it is advisable wherever possible to file an application for a utility patent instead of attempting to secure protection by a design patent.

Generic and Specific Claims

An inventor usually conceives a definite structure embodying his invention. Then, as he considers the matter further, other forms of the invention occur to him. In filing his application for a utility patent, he often includes in the application the preferred form of the invention and also specific modifications embodying the other forms that have occurred to him. Where the Examiner takes up such an application and finds the claims specifically directed to more than one species of the invention, he will study the claims to determine if there is one allowable claim broad enough to read on all of the species. If the Examiner finds this to be the case, then the Rules of the Patent Office provide that applicant may claim specifically several species, but in any case not more than three species. This is merely a rule of procedure in the Patent Office, therefore, if a patent should issue with claims specific to more than three species, the patent would not be invalid because of this fact. If, however, the Examiner does not find a generic or broad claim which reads on at least the several species disclosed and claimed, the Examiner will reject all of the claims and will require the applicant to limit the claims to one or perhaps two species. In this case, as in the case where different inventions are disclosed and claimed in one application, the applicant must elect to claim one or two species in his original application, but he may file divisional applications covering the other species providing they are patentably distinct from the one which he has chosen to prosecute in his original specification.

There are several aspects to the including in an application of a plurality of species. It has the advantage of getting a record date in the Patent Office as to all the forms disclosed in the case. It has the disadvantage that there is a tendency to widen the scope of references, on the theory that all of the species are embodiments of one invention and a disclosure of one of these species in a prior art reference may result in a rejection of all claims on the ground that no form disclosed in the application is an inventive concept over the reference found, but that the several forms in the application are merely variations within the skill of the art. This same doctrine applies not only in the Patent Office, but also applies if the application should result in a patent which gets into litigation.

Ordinarily, it is best to disclose only the preferred form of the invention, in which case, the field of search by the Examiner is directed more especially to this single embodiment. If in examining such an application showing a single embodiment, the Examiner should fine a prior art reference which discloses one of the species which the applicant had in mind, but which was not disclosed in the application, the applicant is in a better position to point out to the Examiner the advantages of the particular preferred form which was chosen to illustrate the invention. In this way by disclosing only one form, the applicant may get a patent on his preferred form, where, by the procedure of disclosing all modifications in his application, he may not get any patent at all.

The inventor should, however, disclose all forms of his invention to his attorney. He should, of course, point out what he considers the preferred form, but the less preferable forms, should, likewise, also be disclosed to the attorney for the reason that it enables the attorney to get a better conception of the breadth of the invention. This facilitates the drawing of claims based on the preferred form, which claims will be broad enough to cover such other forms as the inventor can foresee that an infringer might be tempted to use. If the attorney finds it impossible in view of prior art, to draw claims sufficiently broad to cover all of these forms, the attorney should advise the inventor of the situation in order that the inventor may choose what he considers the best form to be covered in one application, also so that the inventor may decide whether or not to cover the other forms in other applications. It sometimes happens that an invention will sub-divide itself into groups of modifications and if there are two general groups of such modifications, it may be possible to cover all of the groups by filing two applications; one in which broad claims may be obtained to cover one group; and the other broad claims may be obtained to cover the other group. In this way, it is possible to cover a wide field by several applications, which field could not possibly be covered in a single application. This procedure is advantageous both in the Patent Office and in the Courts because in each case, the field of applicable prior art is narrowed to a single specific structure. The possibility of obtaining valid patents is greater on several applications than where all the forms are lumped in one application, and also the probability of such patents being sustained in Court is greater for the same reason.

Double Patenting

Where a plurality of applications are filed upon modifications of an invention, it is necessary that the claims in the several applications shall be patentably distinct. It is usually advisable to place the broadest claims in the earliest application. It is all right if claims in the early application are broad enough to cover structures disclosed in later applications, but the Examiner will ordinarily reject claims in the later applications which claims are broad enough to read on the disclosure claimed in an earlier application. The reason for this rejection is the doctrine of "double patenting." Since the patent laws limit the life of a patent to seventeen years, it has been held to

be contrary to the law for a patentee to obtain a patent having claims covering an invention, and then on another application at a later date to obtain a second patent granted at a later date and having claims broad enough to cover the first patent which has issued with claims to the same invention, on the ground that the result would be an extension of the patent monopoly for more than seventeen years. A situation involving such overlapping claims is known as "double patenting." Such overlapping claims in the later patent may be held invalid and consequently such claims in a later filed application will be rejected by the Examiner on this ground if caught by him. If the Examiner misses this point and the patents are granted, such claims in the later patent will ususally be held invalid if the patent gets into litigation. The law on this legal point is somewhat involved and will be treated more fully when defenses to a patent suit are discussed. Double patenting is determined by the claims and not necessarily by the disclosure in the specification and drawings. It is not unusual, though perhaps not the best practice, to find two patents granted on substantially the same disclosure, but wherein the claims in the first patent are drawn to one invention and the claims in the second patent are drawn to a different subject-matter. Ordinarily, it is the better practice where division is required to cancel the figures of the drawings and description in the specification from the original application as to all divisible subject-matter, so that any patent granted on the original application will not disclose the identical form specifically claimed in the divisional case. This procedure results in two patents issuing on distinct disclosures. Broad claims in an early patent and specific claims in a later patent both based on identically the same subject matter is double patenting and the later patent is invalid. This is because two patents have issued on the identical invention. This rule of law is so strictly applied that the Supreme Court held invalid the patent having the higher patent number even though both patents were granted on the same day.

Functional Claims

It frequently happens that an inventor will invent a method or process of producing some product or result, and then will invent a machine or device for the manufacture of the product or for obtaining the result and will file an application for the method of producing the product or result and also for the structure of the machine or device. A method usually comprises a series of steps to produce a product or result, and if these steps are intimately related to the machine, both the method claims and the machine claims may be retained in one application.

There was a time in the history of patent law that method or process claims were not extended to include mechanical processes or methods. It is now well recognized in the law that a process or method claim may properly be based on mechanical, electrical, optical or other steps to produce an article of manufacture or to obtain a new and useful result. For example, a claim to a mechanical method of making reticulated metal work was sustained by the Supreme Court thereby establishing this point in the law. Method claims in all arts, if defining a proper method, are now patentable. If the method is distinct from the machine, and comprises a separate invention, the Examiner may require division. This, as we have previously explained, is the situation where independent inventions are claimed in a single application. One of the tests of a method or process is that it may be carried out by hand and independent of any specific device. Where the alleged method or process is simply the function of a machine, the Examiner will reject on the ground that the claims are "functional." The Examiner may be correct or he may be in error and in the latter case, it may require considerable careful analytical argument to convince the Examiner of his error. One reason for the rejection on the ground that the claims are functional is because the claim is said to be broader than a patentable invention, in that inventions under the statutes must be confined to the four statutory groups, namely, "a new and useful art, machine, manufacture, or composition of matter" and the function of a machine does not broadly come under any of these statutory groups. If the method invention is not the function of a machine, it then comes under "a new and useful art." This rejection of the claims being "functional" is most usually made where claims are drawn in the form of a method or a process claims, which method or process may be carried out only by a specific apparatus.

Lack of Utility

The Examiner may reject a claim on the ground of "lack of utility." This is a somewhat rare type of rejection for the reason that ordinarily, the Patent Office does not consider the question as to whether one device is more or less efficient than another. The principal view the Examiner takes is whether or not the device as claimed is "new" in the art. Lack of utility, however, occasionally is used for a ground of rejection. This type of rejection is usually based upon some article or device which is harmful to society and has no legitimate utilitarian use.

Occasionally, absurd patents get by the Examiners. Some years ago, a preparation was patented under the guise of being a hair grower. When the ingredients were studied by one skilled in the art, the preparation was a perfectly good cocktail. It would be questionable if such a patent were invalid as lacking utility, because there is a doctrine in the patent law that an inventor is entitled to all the uses of his invention whether he knew them or not.

Indefinite Claims

Another reason for rejection is failure to "distinctly claim" the invention in the claims as is required by the statute. Misdescriptiveness comes in

this same class of rejection. A claim must be properly descriptive of the invention even though the language of the claim may be broad. It is the purpose of the claim to define the invention and a properly drawn claim will define the invention as broadly as the prior art will allow, but, by the very nature of a claim, it must, at the same time, distinctly and correctly define the invention.

The individual parts of a machine or apparatus specified in a claim are usually referred to as "elements," and where a claim recites a duplication of elements, such a claim will be rejected on the ground of "duplication." It is really a rejection on the ground that the claim does not distinctly point out the invention.

The same type of rejection is given where a claim is "incomplete," in that each claim should define a sufficient number of elements to produce an operative device. A claim that omits a necessary element will be rejected as "incomplete." A proper claim, however, need not cover an entire machine. For example, in a locomotive there are various groups of mechanisms, such as the steam generating group comprising the fire box and boiler; the driving group comprising the piston, slide valves, valve mechanism, drive wheels, etc.; and the control group comprising the throttle valve, link controls, etc. There might be a possibility of an invention comprising a re-organization of these groups in such a manner as to produce a new locomotive which might be patentable as a whole, and, therefore, carry claims to a complete locomotive. At the same time, in this same new locomotive there might be a distinct improvement in the slide valve construction which would carry claims to this particular construction. The claims on the slide valve would not necessarily recite all of the elements of the locomotive. If the claims on the slide valve covered the slide valve completely, then such claims would not be rejected by the Examiner as incomplete. Such claims are known as claims to a "sub-combination."

Duplicate Claims

Occasionally, the Examiner will reject one claim on another, in that one claim may be allowed and another claim be rejected as not patentably different from the allowed claim because the second claim differs merely by the addition of an immaterial limitation. By this is meant a recitation in the second claim of some characteristic which is inherent in the same element recited in the previous claim and consequently, the legal scope of the two claims is the same. Here again, the Examiner may be mistaken in that the rejected claim might have been so worded as to cover some structure that would not be covered by the allowed claim. If this is the situation, the claims are patentably distinct and both should be allowed.

"No Invention"

After an Examiner takes up a case and reads the claims for consideration, he usually searches his United States and foreign art to find a prior art patent bearing on the invention which the applicant is claiming. In making this search, the Examiner is usually guided by two things. First of all, he bears in mind the specific invention disclosed in the specification and drawings, and secondly, he bears in mind the breadth of the claims in the application. If the Examiner finds a reference disclosing the identical thing disclosed in the drawings and the specification of the application, then he rejects the claims on this reference, and his labors are over so far as this case is concerned because a prior art patent or publication disclosing the identical thing of the application is a complete bar to any patent which would issue on the case. In this case, the Examiner is not likely to criticize the form of the claims because under this condition, since no patent could possibly issue on the application, it would be a waste of time to indulge in criticism. The finding of a complete and perfect reference does not often happen. What does happen is that the Examiner finds some prior art patent which is similar to the device disclosed and claimed by the applicant and on which the claims of the application as a matter of language may read. In this case, he rejects the claims and also criticizes the form of such claims as he thinks are informal. If there is a claim in the case drawn to the specific construction disclosed by the applicant and which claim does not read on the reference, the Examiner may allow the claim, or he may reject this claim on the reference he has found on the ground of "no invention." Such a rejection is difficult to overcome because there is no recognized legal definition of "invention." There are usually some differences in function or advantage in construction between the specific device disclosed by the applicant and the similar device shown in the reference. Perhaps the device of the application has gone into extensive commercial use and this fact may be made of record by affidavits filed in the application file. In such case, the Examiner is likely to allow specific claims which do not as a matter of language read directly on the reference. There is also the legal doctrine that all doubts should be resolved by the Patent Office in favor of the applicant and this is helpful to the applicant in a doubtful case.

Negative Elements

The Examiner will reject a claim which recites as an element an intangible thing such as "a hole," "a space," "an opening," "a vacuum," etc. A claim which recites as elements, for example, "A truss beam comprising a main bar, a hole in the main bar, a cross bar extending through said hole," etc., would be rejected on the ground of reciting an intangible or negative element. One proper way to claim this structure would be, "A truss beam comprising a main bar having a hole through said bar, a cross bar extending through the hole in said bar," etc. The word "conduit" is acceptable since this defines a physical structure in the form of a pipe or an enclosing member, and not the hole through the member. The term "chamber" is also acceptable since it refers to a walled structure, not the space enclosed by the walls.

Some years ago an applicant applied for a patent on a fence in which the claims specified "A fence comprising the combination of stretched woven wire, posts for holding the wires, in combination with the earth in which the posts were set," etc. The Examiner rejected the claim including an element, namely, "the earth," which was not a part of the invention. As a matter of fact, the Examiner probably thought the applicant was trying to cover a bit too much territory. This element "the earth" is far from being intangible, but the basis of the rejection is similar to this ground of intangibility. It frequently happens that improper claims are rejected when an attempt is made to include "the atmosphere," "gravity" or other forces of nature as positive elements of a claim. There is no objection to properly referring to these natural forces inferentially in a claim so long as they are not recited positively as elements of a claim.

Alternative Claims

Claims which refer to alternatives are usually rejected. Occasionally, a claim having alternative elements will get by the Examiner, but such claims are usually rejected as being indefinite. The same result may be reached, however, by a properly worded specification on which the claim is based, for example, assume a self-closing fire door held by a fusible link. If the claim read "A fire door, comprising in combination a fusible link normally holding the door open, and a weight, or spring or vacuum dash-pot to close the door when the link is broken," etc., such claim would be rejected as alternative and indefinite. However, if the specification stated "The mechanism for closing the door may comprise a weight, or spring, or vacuum dash-pot or other suitable operating device" and then the claim was for "A fire door, a fusible link normally holding the door open, and mechanism to close the door when the link is broken" etc., such a claim, if novel, would not be rejected as alternative and yet it would cover all the alternative structures recited in the specification.

While an alternate claim is improper because a claim must be definite to clearly define a single invention, there is no serious objection to alternative structures being recited in the specification. Occasionally, an over zealous Examiner will require alternate structures referred to in the specification to either be illustrated in the drawings or cancelled from the specification. Such criticism by the Examiner, however, is improper if the alternatives are merely well known skill of the art. If they involve inventive concept, then they should either be omitted from the specification or be shown in the drawings and described in the specification as modifications of the invention.

Change in Degree

Where the difference between a prior art reference and the disclosure of an application is one of "degree," the Examiner will usually reject on the ground that a mere matter of degree is not sufficient to produce a new invention, but that the change in structure lies within the skill of the art. There are exceptions to this rule more especially in connection with an invention which opens a new field and changes experimental failures into a practical success. This matter of degree was one of the questions which arose in the Bell telephone case. Bell succeeded because he used a thin diaphragm where others had failed by using thicker diaphragms. Bell had made a real, practical invention whereas his predecessors had merely produced abandoned experiments.

Substitution of Material

Ordinarily, substitution of material is not recognized as being an invention, and the Examiner will reject on the ground that substitution of material lies within the skill of the art. There are also exceptions to this rule and these exceptions apply usually to an old art in which a somewhat unusual material is introduced to produce very desirable results that were not foreseen. The famous example in this class is that of the use of vulcanized rubber as a basis for a dental plate, in the place of gold or other metals that had previously been used. It was pointed out that rubber possessed many valuable characteristics which solved problems that had hitherto escaped the attention of the dental art and the patent was sustained.

Elements Must be Positively Stated in Claim

The Examiner will sometimes reject a claim as being indefinite where the elements in a claim are not positively recited. For example, if a claim for a door check should read,

> "A door check comprising in combination, a lever having a spring secured to one end of the lever and the other end a spring fastened to an anchor with a link connected to the lever and secured to a door."

this claim would probably be rejected on the ground that the elements are not set forth positively. The better action on the claim would be that it is informal. A better form for the claim would be:

> "A door check comprising in combination a lever, a spring secured to one end of the lever, an anchorage for the free end of the spring, a link secured to said lever, and a fastener securing the link to the door."

This claim is merely suggested as a matter of form and not with any intention of referring to novelty one way or the other. The first claim is informal because the elements of the claim are not distinctly defined, whereas in the second claim each element is distinctly set forth.

"Fugitive" Element

Claims which include as an element a material which is destroyed in the use of the device are rejected as including a "fugitive" element. For example, if a claim be drawn to cover a recording clock or recording meter, the sheet of paper on which the record is made should not be positively included in a claim intended to cover the mechanism, for example:—

"A recording meter comprising in combination,

a record holder, a record sheet mounted on said record holder, a motor to revolve said record holder, and a pen to make a record on said record sheet."

This claim would be rejected on the ground of including a "fugitive" element. There is no objection referring to this feature inferentially as for example, the claim might be properly written as;

"A recording meter comprising in combination a record holder adapted to carry a record sheet, a motor to rotate said record holder, and a pen to make a record on said record sheet."

An exception to this rule arises where the fugitive element, namely, the "record sheet" performs some function in the operation of the device, as for example, suppose a recording meter which is intended to make one revolution of the record sheet and then stop, and in order to produce this action a notch is cut in one edge of the record sheet or record disc which notch cooperates with a stopping mechanism. In this case, the record disc should be included as an element of the combination, because it is one of the operating elements of the device, and regardless of the fact that a new record is put on each time the device is operated. A proper claim for such a device would be:

"In a recording meter, in combination a record holder, a record disc carried by said record holder, and said record disc having a notch in the periphery thereof, a motor to rotate said record holder, a pen to make a record on said record disc, and a stop mechanism adapted to cooperate with said notch in said record disc to stop said motor when said notch encounters the stop mechanism."

Under the type of rejection based on "fugitive" elements, there arises rejections relating to articles of manufacture. For example, the Patent Office has held that a preformed gob of glass which was intended to be used in connection with the production of a glass article could not be claimed as an article of manufacture for the reason that it was a transitory step in the manufacture of the glass article and that the gob was not an article of manufacture. An article of manufacture ordinarily presupposes something which is complete in itself and may be sold as an article of commerce. This doctrine, however, is not limited to exclude articles of manufacture which may require further operations in order to be saleable. For example, various forms of I-beams have been patented although an I-beam is always used to make up some other structure. Another example of a patentable invention as an article of manufacture is a steel ingot. A steel ingot, while ordinarily fabricated in the steel mill which casts the ingot and usually goes forward during the steps of manufacture without being cooled, is a proper subject for patent and is not a "fugitive" element. It is entirely possible to permit an ingot to cool and be shipped to another plant as an article of commerce where at the other plant, it may be reheated and subsequently rolled or forged into a finished article of commerce.

Illustration and Description Required

Where the subject-matter of a claim is capable of illustration, the Examiner will reject the claim unless the structure on which it is based is shown in the drawings; and conversely where the drawings disclose an invention but the particular feature claimed in the claims is not referred to in the specification, the Examiner will reject the claim. In both cases, the rejection is based on insufficient disclosure. In both cases, proper corrections will be permitted. The proper application will both describe and illustrate (where possible) the invention which is covered by the claims. In certain chemical and alloy cases, the invention cannot be illustrated with drawings, and in such case the claims will not be rejected although they are based entirely upon the specification.

Equivalents

The Examiner will often reject a claim on the doctrine of "equivalents" where the reference does not show the specific thing of the application but does disclose a similar arrangement using elements which will perform the same function. An "equivalent" has been defined as that which performs the same function in substantially the same way to produce substantially the same result as the invention with which it is compared. A weight, under certain circumstances, might be substituted for a spring without in any way affecting the result. In such case, the weight and spring are said to be equivalents. On the other hand, a weight involves the element of mass and inertia and under certain conditions, particularly with a moving part, the weight could not be substituted for the spring. Under these conditions, the weight would not be an equivalent for a spring.

Combination-Aggregation

In patented mechanical structures, the arrangement of elements are usually said to be a "combination." A "combination" may be defined as an arrangement of parts or elements, mechanical, electrical, optical, etc., which cooperate to produce a result which is distinct from the individual functions of the various elements. Of course, each element must necessarily operate in its normal way, according to its mechanical or physical law but the result obtained by the combination of these elements is a new and useful result which is not merely the additive function of the elements.

In contrast with a true combination is an arrangement of elements known as an "aggregation." An "aggregation" of elements usually results from the association of two distinct mechanisms. For example, it has been held that the putting together of a washing machine and wringer by using a common motor with suitable clutches and gearing for operating both machines is an aggregation, on the theory that both of the mechanisms were old and well known and the mere driving of the two mechanisms by a single motor did not cause one mechanism to modify or change the operation of the other mechanism. This re-

jection would be based on the same theory that the running of a number of machines from a single line shaft would not affect the individual operation of the different machines.

A simple illustration of a combination is where element A plus element B produces a result C which is not the sum of the functions of elements A and B. On the other hand, an aggregation may be illustrated as where element A plus element B merely results in the normal function of element A added to the individual function of element B. As a matter of fact, the rejection by the Examiner on the ground of "aggregation" is merely another form of a rejection based upon the ground of "no invention." In other words, the Examiner presupposes that given two machines old in an art, it does not amount to invention to associate these machines in such manner that the function of one does not affect in any way the function of the other.

Combining References

Ordinarily, the Examiner attempts to reject any one claim on a single reference. However, where a rejection is based upon the ground of aggregation, the rejection usually requires at least two references, one showing one machine and the other showing the other machine. Very often an Examiner will combine references to reject a claim which is really a proper combination claim so far as form is concerned. Under these circumstances, the Examiner usually tries to find a main reference showing a machine or device having the elements of the combination but wherein some of the elements may differ from those specifically defined and claimed. In this case, the Examiner may reject on the ground that the claim is not patentable in view of the main reference of the patent to Jones, when the specific elements shown in the patent to Smith are substituted for a certain group of the elements shown in the patent to Jones. The basis of this rejection is that once given the combination to perform a given result, it would be merely skill of the art to use various well known elements in an art in the place of those which the applicant has put together to form his combination. Suppose, for example, the applicant showed a clock mechanism operated by a spring motor, and wherein the clock mechanism had a peculiar reduction gear arrangement between the spring motor and the hands. If the Examiner found a reference showing a prior art clock patent with an arrangement of the peculiar gear-train mechanism run by a weight, and then found another reference showing a clock run by a spring motor, the Examiner would reject the claims on the main reference showing the gear train, in view of the reference showing the spring motor. This combining of references is a favorite ground of rejection by the Patent Office and is often carried too far. It should not go beyond the substitution of equivalents. Sometimes, an Examiner will reject the claims on two references where one reference shows only a part of the combination and another reference shows another part of the combination. Ordinarily, such a rejection is not well taken because nearly every device is made up of old mechanical members arranged in a new way, so that where an Examiner cites a reference showing only a part of the construction and it does not perform the results obtained by the applicant, and then uses some other reference which shows another part of the construction, the Examiner is really re-making the invention himself, after the problem has been solved by the applicant. It is difficult, of course, to look forward rather than backward but the Courts have frequently said that looking backward is not the proper way in which to reject or invalidate a claim, and that problems once solved are easy, but often it is not so easy to find the answer to a problem that has troubled an art for many years until finally someone makes a very simple solution. After it is done, it may be obvious to anyone, but to do it in the first place is a different story.

Double Use—Analogous Arts

As previously stated, an inventor is entitled to all uses of his invention whether he knew them or not. Therefore, ordinarily, the mere "use" of an invention is not capable of being covered by a patent. The patent covers the essence of the invention and not the use. For example, the Supreme Court held that the use of an ice cream freezer type of device to preserve fish was not a patentable invention on the ground of "double use"; and that to place a propelling screw at the front of a steam boat instead of at the rear of a steam boat was held to be double use. Also, that a construction comprising removable cutter teeth on a wheel used for cutting tongues and grooves, was not patentable because of double use when applied to a thin saw for use in sawing materials. These changes were said to have been made in "analogous arts."

A machine used for polishing wood comprising a cylinder provided with glass bars, etc., was held not to anticipate a similar machine using iron bars mounted on a cylinder for grinding clay, on the ground that the art of polishing wood would not suggest any solution to any problem in connection with grinding clay and that even though the clay machine were similar to the wood polishing machine, nevertheless, the arts were not analogous and the wood polishing machine therefore did not invalidate the clay grinding machine. It occasionally happens that in the Patent Office, references will be cited from a non-analogous art and upon a proper presentation of argument, such references will usually be withdrawn by the Examiner.

Inoperativeness

The Examiner may reject an application on the ground of inoperativeness. Where this ground is based upon an error due to mistake of disclosure, as for example, if the error was a draftsman's error or merely a misapplication of skill of the art, correction (as has been previously pointed out)

is usually permitted. If the error resides in the omission of an essential part which goes beyond the skill of the art, the error may be fatal, and no patent can be obtained on such a disclosure. It sometimes happens that the inventor conceives a construction which the inventor and attorney are convinced is operative, but which the Examiner may conclude is wrong in principle, and, therefore, inoperative. The Examiner will reject on the ground of inoperativeness and may demand a demonstration. If the demonstration is successful and shows that the apparatus will work, the rejection on this ground is overcome. It may have happened that the Examiner was confused due to a wrong explanation of the theory on which the invention operated. This may be corrected while the application is pending in the Patent Office; but it will not be fatal even if the patent should issue with the mistaken theory therein, because it has been held that a patent will not be declared invalid because the theory of operation of the invention was entirely wrong, provided, of course, that the specification discloses how to fully practice the invention so that when the patent expires the public may use the invention disclosed. This situation where a wrong theory does not invalidate a patent usually applies to mechanical or electrical cases where the structure is claimed. If the patent involves a method or process and a wrong theory is not only set forth in the specification but also is set forth in the claims, such claims may be held void. In a case where certain things take place, as, for example, in certain chemical reactions, and it is not known just what occurs, it is safer to state in the specification that the theory as to what happens is not well known but it is "believed" that such and such reactions occur. This difficulty does not often arise in mechanical cases, but it may arise in chemistry, electro-chemistry, and occasionally in the electrical arts.

If an application for perpetual motion is filed and the Examiner is convinced that the applicant is attempting to patent a perpetual motion machine, such an application is usually rejected on the ground that perpetual motion devices are not patentable. The ground is not so much based on the impossibility of producing perpetual motion, but it is based upon the broad ground of inoperativeness.

Various definitions may be given for perpetual motion. One of the common definitions is a device which when once started in operation continues to operate indefinitely. This definition usually presupposes that the functioning of the device continues until the device is worn out. Such a definition might include a water wheel operated by an unfailing source of water supply. It might also include a windmill situated where breezes unfailingly blow. It would include an ingenious clock arrangement which is wound by thermal changes in the atmosphere so that a variation in temperature of four degrees is sufficient to wind the clock for twenty-four hours. In most parts of the world, there is at least a four degree change in temperature during twenty-four hours, and, therefore, such a mechanism might come under this definition of perpetual motion. Such devices, of course, are patentable and are not truly perpetual motion devices. If perpetual motion be defined as a self-contained apparatus capable of producing within itself a continuous supply of energy sufficient to operate the device, then we have a condition which has not yet been solved by science and is generally recognized as impossible. It is this type of device which will be rejected on the ground of being a perpetual motion apparatus and the Examiner will require a demonstration. This usually ends the case, because a successful demonstration of such a device has not yet been made. Occasionally, in the distant past, the Examiners have tended to accept only established principles in an art rather than to consider future possibilities and to be skeptical of devices which opened a new door in an art. There is a story told of an Examiner many years ago who rejected an application for a heavier than air flying machine on the ground that no inanimate object heavier than air could be suspended in the air without some anchorage to the earth, like a kite; and pointed out that air was a fluid analogous to water and that for an object to be sustained in this fluid, it must weigh less than the fluid which it displaces. If this Examiner were alive today, he would be somewhat surprised to see the modern airplane of many tons being carried through the air at a speed of over one hundred miles per hour.

Some years ago, there was a rumor, that an attorney filed an application for a client on a machine which seemed to be based on correct mechanical principles. The Examiner carefully analyzed the application of forces applied in the device and the analysis clearly showed the device to be an attempt at perpetual motion. Therefore, the Examiner rejected the case on this ground. The attorney came to Washington and explained he had not seen this fact until the Examiner had pointed it out, but that the inventor was insane on the subject of his invention and had threatened to kill the attorney if he did not get a patent in a set time limit. The attorney convinced the Examiner of the seriousness of the situation and the Examiner allowed the case for the reason that the patent if granted would do no harm, while a refusal might result in the threat being carried out. Ordinarily, the Patent Office is not concerned with the personal relations between a client and his attorney.

A similar case occurred in New York City a few years ago where a patent attorney was shot dead at his desk by an insane client, so that the profession of patent law not only has its difficulties but also its dangers.

The modern inventor, contrary to some opinions, is by no means a crazy man or an eccentric character, but on the contrary is usually a highly educated perfectly normal individual who has developed a new step in the progress of industry or science.

Judging Excess Air From Flue Gas Analyses

By P. B. PLACE, Engineer
Combustion Engineering Corporation

The amount of excess air with which a fuel is burned is usually determined by an analysis of the products of combustion. It is customary to judge the perfection of combustion from the CO_2 content of the dry flue gases. This is quite correct provided the relation between per cent excess air and per cent CO_2 is known for the fuel in question but it is not so generally realized that this relationship is not the same for all fuels. The combustion of a bituminous coal with 30 per cent excess air gives close to 14 per cent CO_2 in the waste gases but the combustion of an anthracite coal, a fuel oil, a natural gas and a blast furnace gas with the same amount of excess air will give products of combustion containing anywhere from 8 to 21 per cent CO_2, depending on the fuel.

Table 1 gives typical analyses of several different fuels. The combustion performance of these fuels has been calculated from their analysis and in Fig. 1, the per cent CO_2 in the waste gases is given for different amounts of excess air. That a statement of the CO_2 in the gases does not indicate a definite excess air for all fuels, is evident.

The percentage of oxygen in the waste gases is a better indicator of excess air. In Fig. 2 is given the per cent of O_2 in the dry gases corresponding to the CO_2 values in Fig. 1. Except for blast furnace gas and producer gas it is seen that the variation in O_2 with excess air is relatively small. Thus at 40 per cent excess air, the maximum variation in O_2 is less than one half of one per cent for coals, fuel oils, natural gases and coke oven gas, whereas the variation in CO_2 under the same condition is 7 per cent.

With greatly increased excess air the variation in CO_2 tends to decrease and that in O_2 to increase so that the advantage of O_2 as an indicator is less evident for excess air of over 100 per cent. Conversely with decreasing excess air the advantage is greater and for the usual range of 15 to 40 per cent excess air, a measured O_2 in the gases may safely be taken as indicating a definite amount of excess air for nearly all fuels.

TABLE I

TYPICAL ANALYSES OF DIFFERENT FUELS

Solid Fuels

		Anthracite Coal	Bituminous Coal	Lignite
Moisture—	per cent by weight	3.4	2.5	35.0
Ash—	per cent by weight	11.5	5.5	12.0
Carbon—	per cent by weight	78.8	79.7	37.3
Hydrogen—	per cent by weight	2.2	5.3	2.7
Sulphur—	per cent by weight	0.5	0.5	0.9
Nitrogen—	per cent by weight	0.8	1.6	0.7
Oxygen—	per cent by weight	2.8	4.9	11.4
		100.0	100.0	100.0

Liquid Fuels

		Fuel Oil No. 1	Fuel Oil No. 2
Carbon—	per cent by weight	83.2	87.0
Hydrogen—	per cent by weight	12.4	11.0
Sulphur—	per cent by weight	0.6	1.2
Oxygen—	per cent by weight	3.8	0.0
Nitrogen—	per cent by weight	0.0	0.8
		100.0	100.0

Gaseous Fuels

		Natural Gas No. 1	Natural Gas No. 2	Natural Gas No. 3	Blast Furnace Gas	Coke Oven Gas	Producer Gas
CH_4—	per cent by volume	98.5	59.1	50.6	...	30.7	5.6
C_2H_6—	per cent by volume	...	14.5	10.9	...	...	...
C_2H_4—	per cent by volume	...	...	...	...	2.5	...
CO—	per cent by volume	...	...	...	30.2	5.6	14.5
H_2—	per cent by volume	...	...	...	1.3	49.7	2.8
CO_2—	per cent by volume	...	25.1	0.1	9.4	2.0	10.5
N_2—	per cent by volume	1.5	1.3	38.4	59.1	8.8	66.6
O_2—	per cent by volume	...	...	...	...	0.7	...
		100.0	100.0	100.0	100.0	100.0	100.0

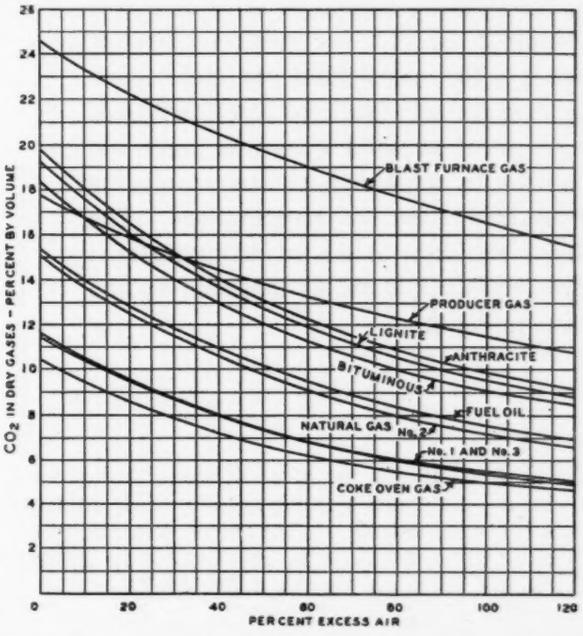


Fig. 1—CO_2 content of dry products of combustion of different fuels

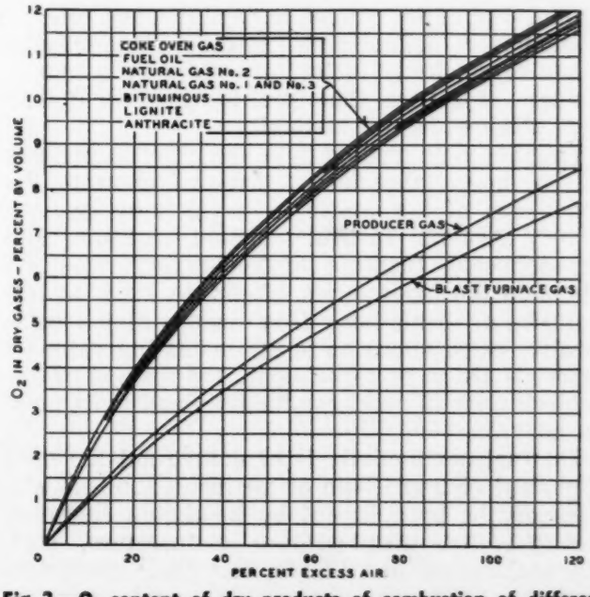


Fig 2—O_2 content of dry products of combustion of different fuels.

Heat Loss Through Insulated Firebrick

By R. C. DENNY, New York

This is a continuation of Mr. Denny's article, "Heat Loss Through Firebrick" published in the August issue. The author points out the variation in heat conductivity constants for different insulations and emphasizes the importance of using constants determined by the hot plate method of testing. The calculations for ascertaining heat loss through insulated refractory walls as compared to solid refractory walls are presented in detail and are accompanied by curves facilitating the computations. The relative thickness of the insulating material is an important factor as indicated by the curves in Fig 8.

THE thermal conductivity of commercial insulating materials varies widely. This fact prevents the application of one set of calculations to all insulations, as is quite permissible in figuring heat losses through standard firebrick.

There is a serious difference in the utility of the conductivity factors given out by various manufacturers of insulation materials. The hot plate method of testing, with its extremely careful, standardized technique, seems to be the only reliable method for determining specific conductivity. When conductivity factors are given by a manufacturer, it is wise, therefore, to ascertain if they were obtained by this method.

This hot plate method is in use today in perhaps half a dozen laboratories, three of them to the knowledge of the writer in engineering schools, namely Armour Institute, Mellon Institute, and Massachusetts Institute of Technology, and the others in the laboratories of certain large manufacturers of insulation. It is obvious that if comparative calculations as to the insulating value of materials are to be relied upon, the method of determining the thermal conductivity constants must be uniform.

Thermal conductivity is of course not the only important characteristic of an insulation. It will assuredly be brought out by insulation salesmen that porosity, disintegrating temperature, cost, practicability of installation, and other characteristics, should each receive consideration. But none of these matters enters into the present discussion, which is confined to a standardized system of calculating the heat transmission through the materials.

The questions that most frequently arise in connection with heat losses through insulated walls are questions of comparison. There is not so much question as between two kinds of insulation as between a selected insulated wall and the solid firebrick wall to which it is being compared. The selected insulated wall, for example, may be one composed of 9 in. of firebrick and 3 in. of insulation. When thus stated, the grade or make of insulation is usually taken for granted. This seems to be the actual situation in very many instances.

When comparison is made with the heat loss through solid firebrick walls, the curves of Fig. 4* may be used for one side of the comparison. But it is quite likely that calculation will have to be made for the other side, because there is no standard combination of firebrick and insulation.

The calculations are somewhat more complicated than those previously discussed for solid firebrick. The reasoning, however, is similar.

Reference to Fig. 5 will assist in the explanation. This typical temperature gradient diagram indicates, by the two sloping lines, the lesser temperature drop through the firebrick and the greater drop through the insulation. But the heat transmitted through each, and emitted from the outside surface of the insulation, as represented by the various letters H with subscripts under each section and outside of the wall, must be exactly equal.

Equations for H_2 and H_3 are of the same form as equation (1) previously discussed, and here repeated; Equation (1) $H = \dfrac{C(T - t)}{S}$

The value of S will depend upon the thickness of the material under calculation, as also will the value of C. For example, when solving for H_3, the value of S will be the inches of thickness of the firebrick wall, and the value of C will be taken from the curve in Fig. 1. When solving for H_2, S will be the thickness of insulation, and C will be taken from the curve for specific conductivity for the particular insulation material selected.

* Figs. 1, 2 and 4, as used in the first part of this article, are included in this installment to facilitate reference.

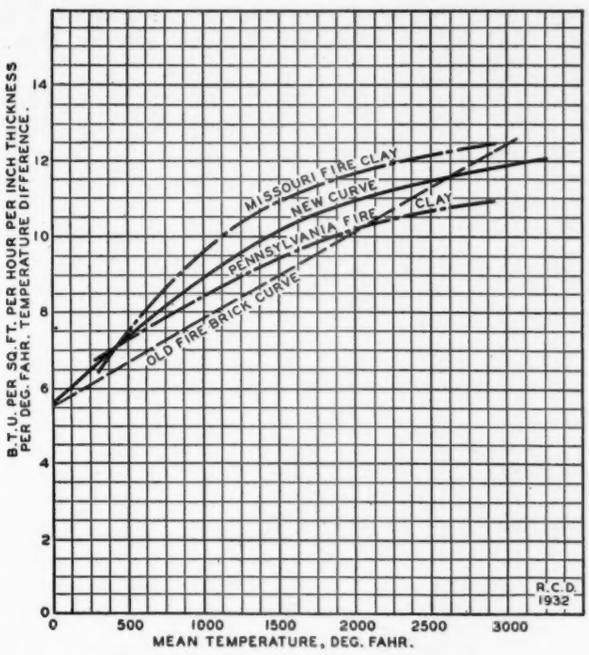

B.T.U. PER SQ. FT. PER HOUR PER INCH THICKNESS PER DEG. FAHR. TEMPERATURE DIFFERENCE.
MISSOURI FIRE CLAY
NEW CURVE
PENNSYLVANIA FIRE CLAY
OLD FIRE BRICK CURVE
R.C.D. 1932
MEAN TEMPERATURE, DEG. FAHR.

Fig. 1—Curves of specific conductivity.

The value of H_1 will be taken from the curve in Fig. 2, as the character of the surface, in this class of work, does not materially affect the emissivity.

Specific conductivity curves for several different insulation materials are assembled in Fig. 6 to illustrate the spread between their conductivity values. Manufacturers' names are omitted, as the conductivity factors alone do not fairly tell the complete story of the respective values of the materials. Each manufacturer will gladly give all of this information to any purchaser or prospect. The engineer who is active in this class of work will of course have this information available through direct contact with insulation manufacturers.

The curves shown are plotted from test data by the hot plate method as determined by one or another of the three engineering schools previously referred to. Curve A is for a material in brick form that combines refractoriness with insulating value. Curve F is for an out-and-out high temperature insulation made by one of the well known manufacturers. Material A will withstand temperatures up to about 3000 fahr., while material F has a limit of about 2500 fahr. but better insulating value. A choice between them would not be made on the score of insulating value alone, but with due consideration of the purpose for which the material would be used.

Curves C and D are for a popular brand of insulation; C is the conductivity curve for the material in plastic form, and D for solid block or dry form. There are many other insulating materials besides those whose conductivity curves B and E are plotted, and many have properly authenticated conductivity data. The six curves shown in Fig. 6 will serve to illustrate a practical and rational method of assembling this information for comparative calculations.

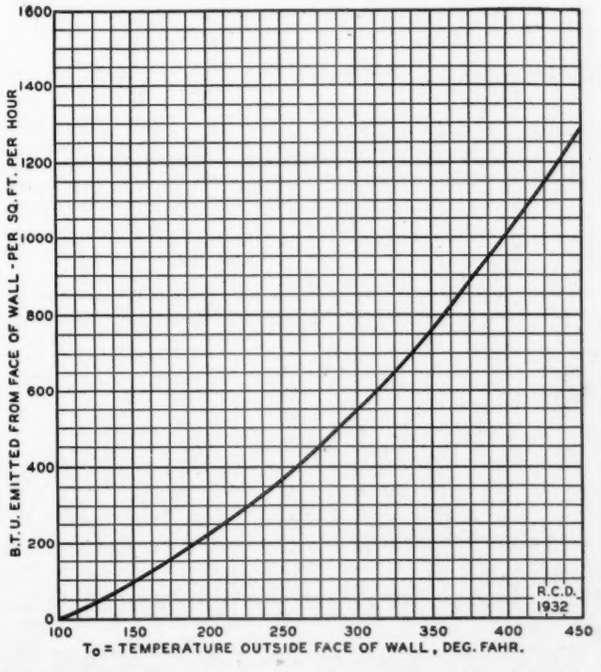


Fig. 2—Emissivity—room temperature (T_r) = 100 deg. fahr.

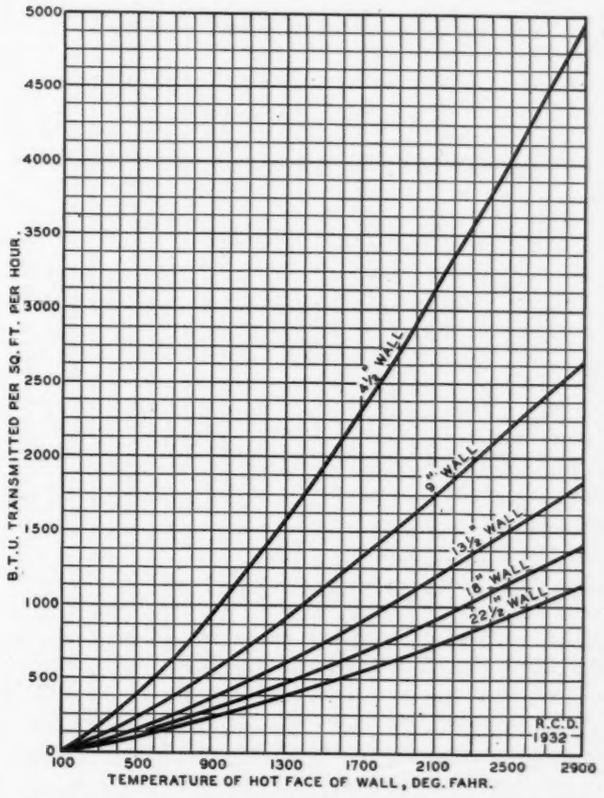


Fig. 4—Heat transmission through solid firebrick at 100 deg. fahr. room temperature.

Comparison is now made between a 22½ in. solid firebrick furnace wall and an insulated wall composed of 9 in. of firebrick plus 3 in. of insulation D, at a hot face temperature of 2000 fahr.

Part of the required information for the 22½ in. wall will be read off of the curve for 22½ in.

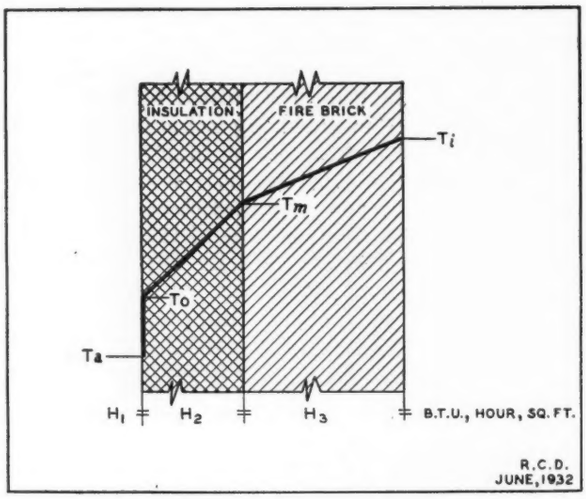


Fig. 5—Typical temperature gradient diagram.

wall in Fig. 4. At 2000 fahr. hot face, the heat transmitted is seen to be 695 B.t.u. per sq. ft. per hr. By reference to Fig. 2, an emissivity of 695 B.t.u. is coincident to a temperature of 335 fahr., which will be the actual surface temperature of the outside of the 22½ in. wall under standard conditions of zero pressure and still air.

To obtain the heat flow through the 9 in. refractory plus 3 in. of insulation D, at 2000 fahr. hot face temperature, first set up equation (1) with an assumed value for the cold face of the refractory (T_m of Fig. 5) at 1625 fahr. The value of C is obtained by reference to the "new curve" of Fig. 1, for the mean of 2000 and 1625, which is 1813 fahr. A reading from the curve for 1813 fahr. mean temperature gives 10.6 as the value for C, and the equation becomes,

$$H = \frac{10.6(2000 - 1625)}{9} = 442 \text{ B.t.u.}$$

The next step in direct order would be to solve this same equation for heat flow through the insulation. But T_o would have to be assumed, and it

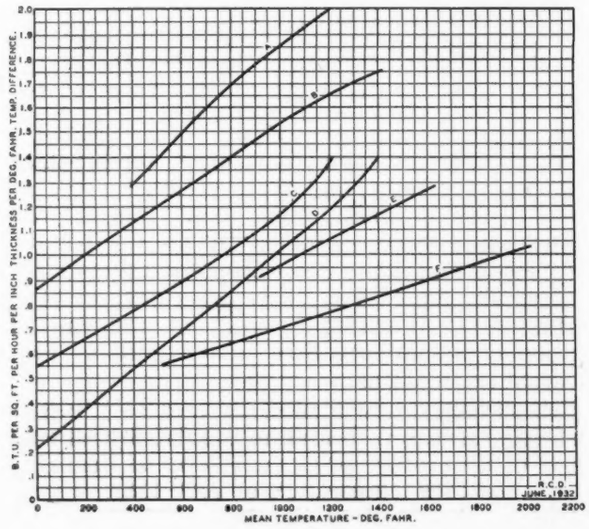


Fig. 6—Specific conductivities for insulating materials.

would be found that this double assumption for each trial would lengthen out the process more than necessary.

Instead, it will prove much quicker to consult the curve of Fig. 2 for the temperature T_o that checks with an emissivity of 442 B.t.u. This is seen to be 270 fahr. and this value for T_o is now used in calculating the heat of H_2 (Fig. 5). The factor C will be read off of curve D in Fig. 6 for a mean temperature of (1625 + 270) ÷ 2 = 948 fahr. and is seen to be .98. These values in equation (1) are,

$$H = \frac{.98(1625 - 270)}{3} = 442 \text{ B.t.u.}$$

and this checks up perfectly with the determination of heat flow through the refractory, and is consequently a solution of the problem.

The two results may now be sketched in two rough heat gradient pictures in order to visualize the results, as in Fig. 7, and several items are notable. The outside surface temperature of the thinner wall is cooler than that of the thicker one. The B.t.u. emission rate is lower for the insulated wall,

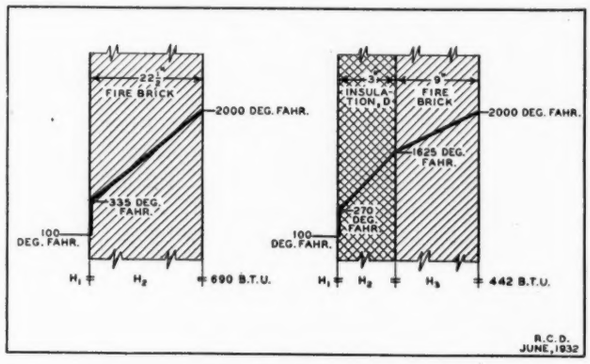


Fig. 7—Comparative temperature gradients.

not because it is insulated but because of the exact amount applied. If only 1 in. of insulation D had been applied to 9 in. of refractory, the B.t.u. emission at 2000 fahr. hot face temperature would have been 822 B.t.u., which is greater than for the solid 22½ in. solid firebrick wall. If 4 in. had been applied, the rate would have been 362 B.t.u. per sq. ft. per hr.

Temperature T_m, which is the hot face of the insulation, as well as the cold face of the refractory, is seen to be 1625 fahr. It is obvious that the insulating material must not disintegrate at or near this temperature. There are a whole flock of insulating materials that are good only up to about 1000 fahr.; these would at once be eliminated for the problem in hand. The material D, for which these particular calculations have been made, is good for 1800-2000 fahr., and the calculations show that these limiting temperatures will not occur, and that it is therefore safe to use this material in this situation.

Further investigation can readily be made by similar procedure if it should be desired to compare

the above with another insulating material such as F, which has a better insulating value, because its conductivity curve is lower on the scale, but which costs materially more than D.

When a certain insulation, or a selected number of insulation materials, are to be frequently con-

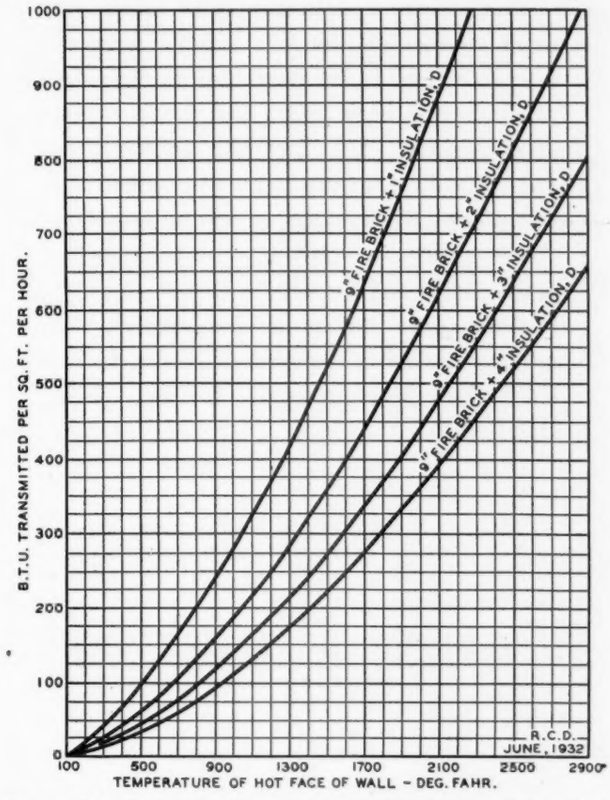

B.T.U. TRANSMITTED PER SQ. FT. PER HOUR.
TEMPERATURE OF HOT FACE OF WALL - DEG. FAHR.
9" FIRE BRICK + 1" INSULATION D
9" FIRE BRICK + 2" INSULATION D
9" FIRE BRICK + 3" INSULATION D
9" FIRE BRICK + 4" INSULATION D
R.C.D. JUNE, 1932

Fig. 8—Heat transmission through firebrick plus insulation D at 100 deg. fahr. room temperature.

sidered, in various combinations of thickness, it will be well to do all the calculating at one time and prepare groups of curves. Choosing between one material or another, and comparing different combinations of refractory thicknesses and insulation thicknesses, is then greatly facilitated. The problem of selection is quickly solved by inspection for heat loss and temperatures, and more time may be given to methods of construction and comparative costs. A simple group of such curves is shown in Fig. 8, where one thickness of firebrick and four different thicknesses of insulating material D are plotted between the heat transmitted and the hot face temperature of the wall.

The publicity literature of the leading insulation manufacturers contains much valuable information in addition to the conductivity of their materials. The curves of Fig. 6 will easily be recognized by reference to this literature, and may be labeled for the reader's personal use.

Those who care to pursue this subject in greater detail are referred to the Bureau of Mines Bulletin 334, to A.S.M.E. paper "Heat Transfer Through Insulation in the Moderate and High Temperature Fields: a Statement of Existing Data", by L. B. McMillan, and to the works of F. H. Norton and Prof. W. Trinks.

Burns & McDonnell Engineering Company Open Cincinnati Office

Due to the increasing amount of business in the central states, the Burns & McDonald Engineering Company has opened an office at 612 Dixie Terminal Building, Cincinnati, Ohio. This office will be in general charge of C. F. Lambert, member of the firm, with H. J. Rosson as Office Manager.

The Burns & McDonnell Engineering Company has been established at Kansas City for 35 years, and has had an office in Los Angeles for the past 10 years. The firm specializes in municipal engineering, including electric light plants, water works, sewer systems, rate investigations, appraisals and reports.

Pyranol—A New Liquid Insulator

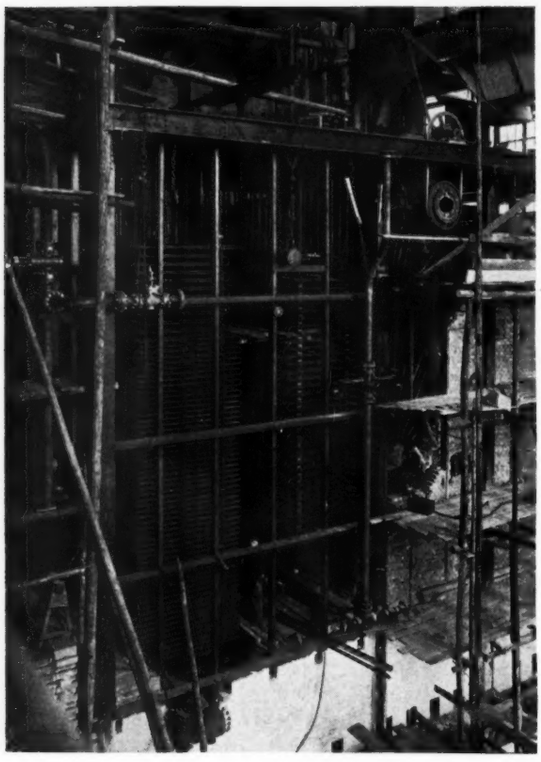
A new synthetic liquid insulator which has been announced by the General Electric Company not only has the advantages of mineral oil as an insulating and cooling medium for electric equipment but in addition is non-inflammable and non-explosive. Designated by the trade name Pyranol, the material is produced in different forms for different purposes, all being synthetic organic dielectrics of varying physical and electrical properties and all having a high dielectric constant.

For economic reasons, mineral oil will probably remain in general use for years, according to General Electric engineers at Pittsfield, Mass., but commercial installations of Pyranol indicate numerous applications where the new material is especially valuable. Capacitors can be made physically smaller per microfarad, with increased reliability, and the higher cost of transformers with Pyranol is justified when the equipment must be completely proof against fire and explosion hazards. Since the liquid is a solvent for some materials ordinarily used in electric equipment, particularly transformers, the apparatus must be designed specially for its use. Its dielectric constant (specific inductive capacity) is practically that of solid insulations, and its dielectric strength is of the same high order as that of mineral oil.

The liquid is chemically stable and it resists oxidation, so that there is no sludging after continued exposure to heat or air. It demulsifies, or separates from water, more than twice as rapidly as does mineral oil, and the moisture rises to the surface, from which it may be evaporated. Viscosity and freezing point can be varied to suit conditions without affecting other qualities of the liquid.

Characteristics of a typical form of the new insulator are:

Color	Water-white
Burning point	None
Viscosity (Saybolt) 40 sec.	(37.8°C)
Pour point (ASTM)	(Minus 30°C)
Dielectric constant	5



No. 3 high-pressure boiler unit now in course of erection at the Renate plant.

The Renate lignite mine and briquetting plant typifies the modern trend toward the use of higher steam pressures in industrial plants having both power and process steam requirements. Mr. Brownlie describes the two 1700-lb. pressure units now installed in this plant. These units, as can be seen from the accompanying drawings, are of somewhat novel design and are fired by lignite-burning, inclined grate stokers in combination with pulverized fuel in the form of lignite dust. A third high-pressure unit is now being installed.

Description of 1700-lb. Steam Plant of a German Industrial

By
DAVID BROWNLIE, LONDON

THERE is no need to emphasize that one of the inherent defects of the ordinary power station operated by condensing steam turbines is the loss of about 55 to 60 per cent of the total heat of the coal in the cooling water. Consequently the ideal arrangement is the use of back-pressure turbines, operated under super-pressure conditions, generating power by the fall in the steam pressure only, while utilizing all the exhaust steam for process and general heating work, and so preventing the latent heat of steam loss.

There are of course throughout the world thousands of smaller back pressure engine and turbine plants running with low steam pressures at the stop valve, say below 250 lb. per sq. in., not only in industry but also for such applications as the steam heating of large buildings, generating power and utilizing the exhaust. Excellent results are being obtained in this way, probably on the average well over 50 per cent thermal efficiency, figures that cannot be approached by any super-power station with condensing turbines.

The latest tendency, however, for large industrial plants is to use water tube boilers of the most advanced super power station type, with say 1200 to 1900 lb. per sq. in. pressure and 800 to 900 fahr. superheated steam temperature, in conjunction with back pressure turbines, the whole installation being so designed as to provide all the low pressure steam required, with sale of any surplus electricity that may be produced. There are now an appreciable number of such modern super-pressure industrial plants in the world, especially in the United States, Great Britain, and Germany.

One of the most interesting of these is at the Renate lignite mine and briquetting plant of the Ilse Bergbau A. G. in the East Elbe district of Germany, now being extended, with "Borsig" boilers operating up to 1700 lb. per sq. in. pressure and 890 fahr. superheated steam temperature.

Through the courtesy of the A. Borsig Gesellschaft of Berlin I am able to give a description of this plant, and to use the photographs reproduced herewith.

It will be remembered the German lignite briquetting industry operates generally on the standard principle of having the briquette factory adjoining the lignite mine, which is of the open-cut or strip variety, operated by huge, endless-

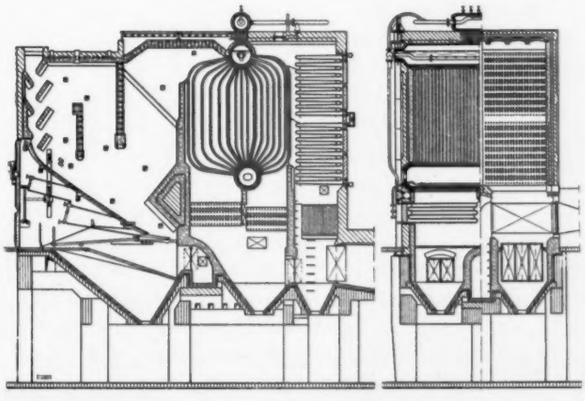
chain, multiple-bucket, dredger excavators both for the lignite and the overburden. The raw lignite, which contains as a rule 55 to 62 per cent moisture, depending on the locality, is dried down to the hygroscopic limit of about 15 to 17 per cent moisture in externally-heated steam dryers, often of the rotary cylindrical variety, and then briquetted direct without a binder in high pressure extrusion or "sausage" presses, consisting of long steel tubes narrowing at the discharge end, through which the pre-dried lignite is forced by rams. A very large amount of low pressure steam is required for the purpose, and the latest German practice is to operate a power plant with super-pressure boilers fired by raw lignite and back-pressure or pass-out turbines supplying all the required steam to the dryers, and generating the necessary power to operate the mine and the briquette factory, with sale of the surplus.

As a rule in the East Elbe district there is 56 to 58 per cent moisture in the raw lignite and the steam used for the dryers is within the range of 25 to 60 lb. per sq. in. pressure. Also when live steam is used from a low-pressure steam boiler plant without back-pressure turbines or engines, according to the older practice, 1 kilo of briquettes (2.2 lb.) requires 1.5-1.6 kilos (3.3-3.5 lb.) of steam for drying. With modern methods this steam is supplied from back-pressure turbines while producing a large amount of power as a by-product, and the boiler pressure adopted is chosen for the conditions, to avoid the use of condensing plant.

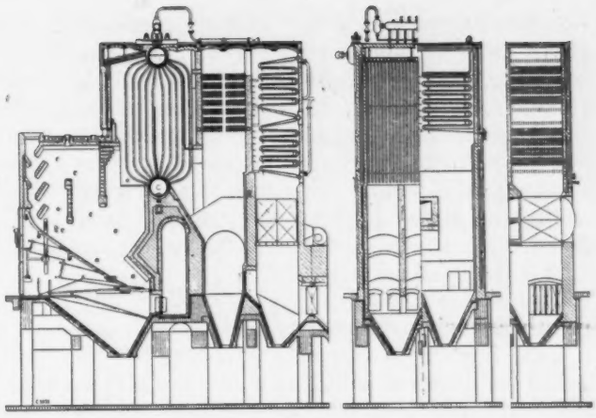
As regards the actual briquetting of the pre-dried lignite the power taken does not vary, but for a complete lignite establishment, including the mine as well as the briquette factory, the figures differ considerably depending on the nature of the lignite seam, the overburden that has to be removed, and the amount of water pumping involved.

Another important consideration also is the site of the lignite mine, and if this is situated near a town or industrial area where surplus electricity can be sold, then it is a paying proposition to operate the boiler plant at the highest possible pressure, so as to increase the power production.

It was because of the favorable circumstances in this latter connection that the Ilse Bergbau A. G.



Sectional elevations of No. 1 Borsig boiler at the Renate plant.



Sectional elevations of No. 2 Borsig boiler at the Renate plant.

decided to replace the old and worn out plant at their Renate briquette factory, with a new boiler and power plant using super-steam pressure.

Accordingly in August, 1928, they instructed the Allgemeine Electricitats Gesellschaft (A.E.G.) of Berlin to investigate the problem with a view to constructing a modern plant of the most efficient character to suit the circumstances. Following on detailed collaboration between the two firms it was decided to adopt maximum pressure conditions of 1700 lb. per sq. in. gage pressure.

The design of the complete boiler house allows for a normal production, for briquetting, of 191,748 lb. of steam per hr., with a maximum output of 213,788 lb. In addition to this, there is required approximately 17,632 lb. of steam per hr. on full load for re-heating of the steam between the stages of the turbine. To meet these requirements, four boilers will ultimately be required, one being a standby, each boiler having a normal output of 75,000 lb. of steam per hour, with a maximum output of 88,000 lb. of steam. At the present time two boilers have been installed by the A. Borsig G.m.b.H. Berlin-Tegel, for 1700 lb. per sq. in. pressure, but normally operating at 1630 lb., so as to avoid any unnecessary blow-off at the safety valves, together with a superheated steam temperature of 890 fahr. This corresponds to a normal pressure of 1500 lb. per sq. in. and 840 fahr. at the turbine stop valve under the particular conditions of the superheaters and steam pipes.

Each boiler is equipped with an air heater and a relatively small feedwater economizer, the size of the latter being determined by the fact that the water is supplied at a high temperature of 265 fahr., being the condensate from the rotary cylindrical steam-heated lignite dryers, and at a pressure of about 35 lb. per sq. in. The whole arrangement in this connection operates as a closed circuit.

Under normal conditions, the combustion gases leaving the boiler are at a temperature of about 480 fahr. while the air heater raises the temperature of the air for combustion to approximately 375 fahr.

The No. 1 boiler has a heating surface of 5520 sq. ft., corresponding to a production therefore

on normal evaporation of 13.5 lb. of steam per sq. ft. of heating surface and 16.0 lb. at maximum working. There are two Krupp 5 per cent nickel, forged-steel headers, each 3 ft. 4 in. internal dia., the length of the upper drum being 23 ft. 9 in. and the lower 23 ft., while the thickness of the steel walls is 4 in. Also there is included at the top of the boiler a forged-steel steam collector 2 ft. 3½ in. internal dia. with 2 in. walls, constructed of 1.5 per cent nickel steel.

The superheaters for No. 1 boiler are two in number, each of which is in two sections, having a total heating surface of 2570 sq. ft. The feedwater economizer is built up of plain wrought-iron tubes giving a total of 7350 sq. ft. to raise the feedwater from 260 fahr. to 520 fahr. The air heater supplied by the Vereinigte Ekonomiserwerke of Dusseldorf, has 7750 sq. ft. of heating surface.

The flow of the combustion gases is through the front rows of the boiler from the top downwards, the superheater, the rear row of boiler tubes from the bottom upwards, the feedwater economizer, and the air heater from the top downwards to the main flue.

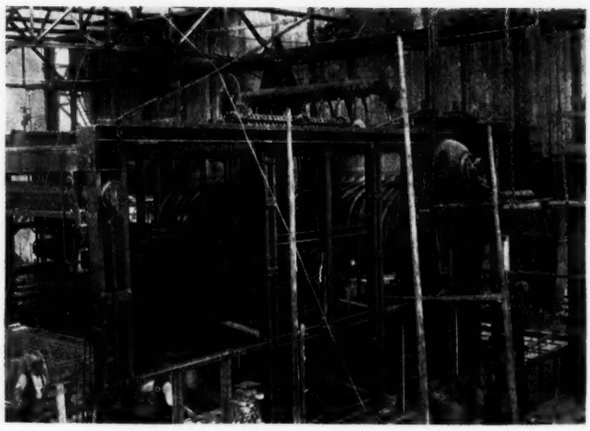
As regards the No. 2 boiler, this is of somewhat different construction, having a heating surface of 5000 sq. ft., giving a normal evaporation of 15 lb. per sq. ft. of heating surface and 17.65 lb. under maximum load conditions, that is respectively an evaporation of 75,000 and 88,250 lb. per hr. The upper and lower drums, of Krupp forged nickel steel as before, have an internal diameter of 3 ft. 4 in. and a wall thickness of 4 in., while the length of the upper drum is 26 ft. 3 in. and the lower drum 24 ft. 3 in. Included is a small steam collector, 1 ft. 2 in. internal dia., with a wall thickness of 1.8 in. and a length of 14 ft. 5 in. The arrangement of the tubes is more compact than in the first boiler.

The superheater has a surface of 6450 sq. ft. and as in the No. 1 boiler, is arranged in two connected sections, each of which is also sub-divided. The feedwater economizer has 9130 sq. ft. of heating surface and raises the temperature of the feedwater to 515 fahr. The air heater in this case is supplied by the Rotator Maschinenfabrik Apparatebau Gesellschaft of Berlin-Charlottenburg and has a heating surface of 8600 sq. ft.

In this boiler the combustion gases travel upwards through the front half of the boiler tubes, downwards through the rear half of the boiler tubes, and then respectively through the superheater, feedwater economizer and air heater to the main flue.

Included also in the superheater equipment of both boilers is a Spuhr steam cooler between the first and second sections, so that the temperature does not exceed 890 fahr. This is operated by an Askania automatic thermostatic regulator so that any desired small amount of cooling water can be sprayed into the steam between the two superheaters.

Each boiler is operated mainly by three inclined grate mechanical stokers supplied by Keilmann & Volcker of Bernburg, each of which is 3 ft. 6 in. wide. These burn raw lignite with 58 per cent moisture, 4 per cent ash, and a heating value of 3600 B.t.u. per lb. The Keilmann & Volcker stoker is of course well known in Germany, especially for burning lignite. It gives a pronounced degree of pre-drying in the upper part of the setting beneath the hopper, the lower part consisting of inclined, slowly moving bars 3 ft. 9 in. long operated with rods.



Borsig No. 2 boiler under construction at the Renate plant.

Each boiler is also equipped for auxiliary pulverized fuel firing, using A.E.G. equipment of the bin-and-feeder type which is put into operation only under peak load conditions to supplement the mechanical stokers. For this purpose the finely divided raw lignite is used, separated by electrostatic dust separators forming part of the briquette plant. This dust is delivered by means of A.E.G. air transmission equipment through pipe lines 330 ft. long, leading to the hoppers for both boilers. Below these hoppers are the pulverized fuel feeders and the blowers, which discharge a regulated mixture of pulverized lignite and air to a distributor head for the six burners of each combustion chamber. The normal capacity of this pulverized fuel equipment is sufficient to take 20 per cent of the total boiler load, the hoppers for the finely divided lignite holding a supply sufficient for five hours.

The plant is served by a single stack 426 ft. high, having an internal diameter at the top of 16 ft. 3 in.

The boiler feed pumps consist of three turbine units manufactured by Escher Wyss & Co. of Zürich, Switzerland, only one of which is used at a time. In two cases the drive is by means of direct-coupled multi-stage turbines, while the third pump, which is purely an emergency unit, is direct coupled to a single stage turbine. All these turbines operate at 185 lb. per sq. in. pressure and 535 fahr. at the stop valve, with a back pressure of 49.6 lb., exhausting to the pipe lines for the lignite dryers.

The main turbine plant consists of two A.E.G.

back-pressure and extraction units, each having a normal duty of 12,000 kw., running at 3000 r.p.m. with normal conditions at the stop valve of 1420 lb. per sq. in. and 840 fahr. superheated steam temperature, although if necessary the maximum conditions in this respect may be 1560 lb. per sq. in. and 877 fahr.

The total amount of steam required for the briquette factory, approximately 187,340 lb. per hr., is extracted from the end of the second turbine casing at 192 lb. per sq. in. and 428 fahr. for reheating. Normally 89,040 lb. of this steam is reheated by means of live steam to 545 fahr. and supplied to the briquette factory for operating the presses, as well as the feed pumps. The remainder of the steam, 98,298 lb., is expanded in the low pressure end of the turbines down to 35.5 lb. per sq. in., and used in the rotary dryers for the raw lignite, with the condensed water returned to the boilers as stated.

The No. 1 boiler was put into service on November 28, 1929, and the No. 2 on June 17, 1930. As a result of the satisfactory performance of these units, No. 3 boiler is now being erected, and will be running before the end of the year. Details of the exact design are, however, not yet available.

It is interesting to note also the general design and construction of the buildings of this Renate mine boiler plant, all of which are alike as regards steelwork, foundations, lighting, and ventilation. One feature, for example, is the use of rigid steel frame structures, while the outside walls are composed of yellow tiles, with roofs of reinforced concrete, the latter—in the case of the turbine house—including a layer of cork insulation 1¼ in. thick.

The Utility Service Company, Indianapolis, Ind., has just been incorporated to finance and construct municipal light plants, sewerage disposal and water supply systems. This organization will function under the direction of Elmer G. Wenz, President.

Universal Valve & Fittings Co., Cleveland, has been appointed agent in that district for Kieley & Mueller, Inc., New York City, manufacturers of pressure control devices and allied specialties. A suitable stock of Kieley & Mueller Full-Range devices will be carried.

Brady & McGillivrey wish to announce that George B. Mulloy has joined their organization as a partner and that they will conduct their business under the name of Brady, McGillivrey & Mulloy, with offices at 37 West Van Buren Street, Chicago, Ill.

Annual Meeting of the American Society of Mechanical Engineers

The 1932 Annual Meeting of the American Society of Mechanical Engineers will be held December 5th to 9th. Among the papers to be presented at this meeting of especial interest to *Combustion's* readers are the following:

Theories of Strength.
Working Stresses for Columns and Thin-Walled Structures.
Stress Concentration Phenomena in Fatigue of Metals.
Application of Creep Tests.
Metals at High Temperature-Test Procedure and Analysis of Test Data.
Public Hearing on Test Code for Centrifugal Compressors, Exhausters and Fans.
Influence of Bends in Inlet Ducts on the Performance of Induced-Draft Fans.
Concerning Notched Bar Tests.
Allowable Working Stresses Under Impact.
Suggestions on Choice of Working Stresses.
Progress Report of Applied Mechanics Division.
Observation of Liquid Water in Steam Passages and Means of Effecting Separation.
High-Pressure Steam-Generator Research.
Progress Report of Power Division.
Stoker Development at Delray Power House No. 3, The Detroit Edison Company.
Problems of Modern Pump and Turbine Design.
Progress Reports of Thermal Properties of Steam Research Committee.
Stresses in Boiler Tubes Subject to High Rates of Heat Absorption.
A System for Measurement of Steam with Flow Nozzles for Turbine Performance Tests.
Performance of Modern Steam-Generating Units.

Huge Welded Transformer Car Passes Preliminary Tests

A huge steel car, developed by General Electric engineers for the transportation of transformers, recently passed its first tests at the Schenectady Plant of the company. The new car, with the exception of the trucks, is of welded construction and marks a new departure in car design. It is estimated that over 5000 ft. of welding were used in the assembly process.

For testing purposes, the car was loaded with 141 tons of pig iron, or approximately 11 tons in excess of its designed capacity. With this total load of about 52,750 lb. on each of its eight axles, the car was hauled over curves and grades. The load was then left in the car for some hours and tests were made for deflection in the springs and structural members.

The car, which is of unusual size, is 60 ft. long and 10 and one-half ft. in width. It is provided with two lifts, one of two feet, and the other of three and one-half feet. Its height above the rail, without either lift, is 10 feet. With the lifts, its height is 17 feet. The weight of the car alone is 141,000 pounds. The tank is constructed of steel, three-sixteenths of an inch thick, welded to stand a gas pressure of five pounds per square foot. When the car is put into service, its tank will be filled with gas to prevent the accumulation of moisture.

REVIEW OF NEW TECHNICAL BOOKS

Any of the books reviewed on this page may be secured from
In-Ce-Co Publishing Corporation, 200 Madison Avenue, New York

Water Analysis

For Sanitary and Technical Purposes

By Herbert B. Stocks

PUBLIC health officers, city chemists and those engaged in the study of this branch of analytical work will be interested in this new edition of a book which has long been a standard in this country and England on the subject of the methods adopted for the analysis of waters for sanitary and technical purposes. It has been completely revised, rearranged and added to by W. Gordon Carey.

Modern developments have necessitated new sections dealing with hydrogen ion concentration, the determination of free chlorine in chlorinated water, and the determination of iodides. A section on simple bacteriological methods is included in this edition, and should prove of service to those who use this book.

The subject is divided into three parts, as follows: Physical Examination; Chemical Examination; Bacteriological Examination. There are eight appendices covering subjects such as standards of purity recommended by the Rivers Pollution Commissioners, tabular view of the standards for effluents adopted by various authorities, average composition of unpolluted water, etc. A comprehensive index makes reference to this volume easy.

The book contains 135 pages, size 7½ x 5. Price $3.50.

Kempe's Engineer's Year-Book For 1932

THIS publication brings together all the technical information which an engineer has to use day by day. It is a library in itself, a veritable encyclopaedia of modern practice in civil, mechanical, electrical, marine, gas, aero, mine and metallurgical engineering. It is of value to the practicing engineer, the consultant, the manufacturer, power user, contractor, works manager, draftsman and technical student.

In this new edition, the 39th, up-to-date information and tables have been introduced, old matter re-arranged, and obsolete material omitted.

The book is divided into 47 sections, among which are the following: Arrangement and Construction of Engineering Workshops—Workshop Practice; Flour. Cotton. Oil, and Sugar Mills and Machinery; Power Transmission; Hydraulics—Pumps—Development of Water Power—Water Pressure Engines—Hydraulic Rams; Sewerage—Sewage Disposal; Metering of Water, Air, Gas, Steam, and Coal; Steam—Steam Generating Plant—Reciprocating Steam Engines—Steam Turbines—Steam Accumulators—Condensing Plant; Internal Combustion Engines; Fuels—Solid, Liquid, and Gaseous; Electrical Engineering; Naval Architecture and Marine Engineering; Heating—Ventilation; Mining and Mining Machinery; Metallurgy; Welding and Cutting; Patents—Trade Marks—Designs; Depreciation of Plant.

This book contains approximately 3000 pages, size 7 x 5, and is profusely illustrated. Price $7.00.

World Economic Survey 1931-32

THE first *World Economic Survey,* issued by the League of Nations, gives a comprehensive review of the development of the world depression up to the middle of July, 1932.

The Survey presents in a single brief and readable volume a bird's-eye view of economic development in the world as a whole. Illustrations are drawn from different countries or groups of countries, but the description throughout is of world problems and world tendencies.

The first chapters set forth the elements of instability in the post-war economic situation, movements of population and of industrial production, the increasing rigidity of economic organization, the shifts in international indebtedness and trading relationships resulting from the war. Special stress is laid upon the importance of movements of capital from one country to another and upon the relation of the credit expansion of 1925-29 to such capital movements.

The main body of the Survey consists of an analysis of the developments of the depression in its various aspects:—the disorganization of production, prices and trade; the difficulties that have arisen in the balancing of international accounts; the growth of unemployment; the strain on the public finances of most countries; and the drift of commercial policy towards increasing measures of trade restriction. A final chapter surveys the position that existed in July, 1932, and the various international measures under consideration as a means of escape from the crisis.

The Survey is illustrated with a number of maps and diagrams, including a series of maps showing the growth of the world's population, and an elaborate diagram illustrating the course of the depression in 35 different countries.

This book is cloth bound and contains 327 pages, size 6¼ x 9½. Price, $2.50.

NEW CATALOGS AND BULLETINS

Any of the following publications will be sent to you upon request. Address your request direct to the manufacturer and mention COMBUSTION Magazine

Air Pressure Soot Blowers

A pamphlet has just been published describing the Diamond Air Puff Soot Blower Systems for fire-tube and water-tube boilers. The operation of these systems is simple and, with the exception of the hand-operated air control valve for each boiler, is entirely automatic. The pressing of a button starts the compressor, and when air pressure in the tank has reached 120 lb., the pilot valve opens the main control valve, and the blower mechanism begins operation. The blower rotates and blows in puffs as long as air pressure remains between 80 to 120 lb. or until its arc has been completed, at which time the first boiler has been cleaned. The operation above described is for fire-tube boilers. That for water-tube boilers is practically identical. 4 pages, 8½ x 11.—Diamond Power Specialty Corporation, Detroit, Michigan.

Belt Conveyors

Conveyor belt problems in many industries, advantages of the belt conveyor, details of belt construction and suggested applications are discussed in "How Shall We Handle It," a recent publication of the Diamond Rubber Company, Inc., Akron, Ohio. This booklet shows how the question of handling many types of materials has been answered in a large number of plants. Specific plant problems, adaptability and versatility of the belt conveyor, and use of conveyor belts in the various industries are described and illustrated. 24 pages and cover, 8½ x 11.—The Diamond Rubber Company, Inc., Akron, Ohio.

Boiler Feed-Water Treatment

"No Scale, No Sludge, No Mud—The application of Zeolite Water Softeners to the treatment of Boiler Feed Water," is the title of a very complete booklet just published by The Permutit Company. It is profusely illustrated with photographic reproductions and diagrams and contains tabulated data, conversion tables, factors, reactions, etc. 36 pages and cover, 8½ x 11.—The Permutit Company, 440 Fourth Avenue, New York.

Boiler Meters

Bulletin No. 44, entitled Bailey Meters, discusses in detail the problem of economical boiler operation from the standpoint of combustion efficiency, and describes how Bailey Boiler Meters fill the specific need for a complete boiler operating guide. Details on how the meters are constructed, the method of installation and the results accomplished by their utilization, are given. Throughout, the bulletin is profusely illustrated with photographs and drawings showing installation views and various applications. Several large colored reproductions of actual chart records are also included. 36 pages, 7¾ x 10½.—Bailey Meter Company, Cleveland, Ohio.

Dischargers

The Cochrane Discharger, a pilot operated steam trap, is described in Bulletin 694. This device differs from ordinary steam traps in that two solid displacement bodies mounted upon an oscillating beam are used instead of a float operating a pilot valve which admits steam to a cylinder containing a plunger actuating the main or discharge valve. Ample power is available for operating discharge valve of any size, so that any desired rate of discharge may be had regardless of pressure, whereas in an ordinary trap having an unbalanced discharge valve the force is limited by the ability of the float or bucket to pull the valve from its seat against the pressure within the trap. The main valve, which is steam actuated, opens and closes positively and almost instantaneously. 4 pages, 8½ x 11.—Cochrane Corporation, Philadelphia, Pennsylvania.

Flue Tools

Catalog No. 57 describes the numerous flue tools manufactured by the Gustav Wiedeke Company. This very comprehensive catalog lists the tools for water-tube, return-tubular, marine and locomotive boilers; also the tools for condensers, heaters, burners and similar units. This catalog is profusely illustrated and contains tables giving list prices and sizes. 96 pages and cover, 7 x 10.—Gustav Wiedeke Company, Dayton, Ohio.

Multiple Retort-Underfeed Stokers

A new catalog has just been published describing in detail the features of the Model "R" Riley Multiple Retort-Underfeed Super Stokers. The construction and assembly of these stokers are illustrated with clear photographic reproductions. 18 pages and cover, 8½ x 11.—Riley Stoker Corporation, Worcester, Massachusetts.

Refractory Cement

A new bulletin has recently been issued describing the numerous features of R & E ♯3000 Refractory Cement. This material, though specifically prepared for laying brick is equally applicable for hot or cold patching and for wash coating. This cement is claimed to air-set to full strength without firing, to have excellent strength at low temperatures, that it can be used for both high or low temperature service, and that it will not puff, bloat or spall at the high temperatures (up to 3000 deg. fahr.) for which it is recommended. 4 pages, 8½ x 11.—Refractory & Engineering Corp., 381 Fourth Ave., New York.

Steam Specialties

H. Belfield Company has published a general loose-leaf catalog consisting of various catalogs and bulletins describing its numerous products. The pamphlets now included are as follows: Catalog No. 10, Belfield Valves; Catalog No. 9-B, Belfield Regulating Valves; Bulletin L-L-32, Liquid Level Controls; Bulletin No. 32-E.R. Belfield Equipoise Rotary Shaft Regulating Valves; Catalog 6-D, Belfield Pressure and Pump Regulators; Belfield Adjustable Shock Absorber; Bulletin 3T, Belfield Transfer Valves; Bulletin 2H, Belfield Extra Grade Butterfly Valves; Bulletin 518 Schaeffer Bypass; Catalog 3—Iron Belfield All Iron Specialties. 8½ x 11—H. Belfield Company, Philadelphia, Pa.

Steel Chains for Power Transmission Elevating and Conveying

Book No. 1192 issued by the Link-Belt Company describes very comprehensively its steel chains for power transmission, elevating and conveying. These steel chains shown in the book form a complete line which has been developed in a wide range of strengths, pitches and types to meet the present-day requirements for steel sprocket chains. The sizes range from the small Steel Link-Belt (No. 25) having an ultimate strength of 950 lb., to powerful chains having 1,500,000 lb. strength. 144 pages and cover, 6 x 9.—Link-Belt Company, Chicago, Illinois.

Temperature Controllers

Bulletin No. 177 describes the Foxboro Temperature Controllers. These controllers are applicable to the food, textile, paper, tanning, ceramics, chemical, metal and other industries. The main headings in this comprehensive bulletin are: Industrial Uses, Temperature Control, Operating Principle and Construction Features. Then follows a description of the various types of controllers and their constituent parts. 48 pages and cover, 8½ x 11.—The Foxboro Co., Foxboro, Mass.

NOTICE

Manufacturers are requested to send copies of their new catalogs and bulletins for review on this page. Address copies of your new literature to

COMBUSTION
200 Madison Ave., New York

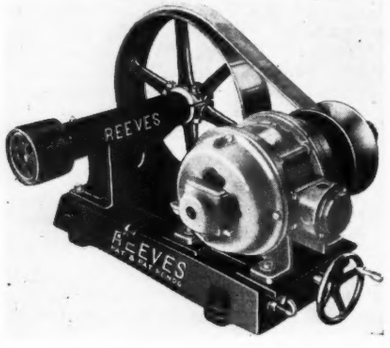
NEW EQUIPMENT

of interest to steam plant Engineers

Variable Speed Unit

Reeves Pulley Company, Columbus, Ind., manufacturer of variable speed control units, announces the Reeves Vari-Speed Motor Pulley Countershaft Unit, an adaptation of the Reeves Vari-Speed Motor Pulley especially designed for unusual speed reduction or increased speed.

This new unit embodies the fundamental design of the standard Vari-Speed Motor Pulley, which consists of



two opposing cone-faced discs, one stationary and one sliding, and an adjustable power compression spring all mounted on the shaft of a standard electric motor. This assembly is mounted on a special sliding motor base. A V-belt forms the connection between the sliding discs and the driven pulley. A turn of the adjusting handwheel in one direction moves the motor and disc assembly toward the driven pulley; in the other direction, away from it. As the motor pulley moves away from the driven pulley, the sliding disc moving out laterally, the V-belt travels over a smaller diameter between the discs, thus effecting speed reduction. When the handwheel is operated to move the motor toward the driven shaft, the V-belt will operate from the small to the full diameter of discs, consequently providing increased or maximum speed on the driven machine.

The new unit employs a special ball bearing countershaft on one end of which a flat-faced pulley is mounted. This pulley receives power from the Vari-Speed Motor Pulley and motor. On the other end of the countershaft, any standard type of drive, such as pulleys, multi-V-belts or chain and sprockets can be applied to transmit the power and provide the speed variation required on the driven machine. The countershaft itself is adjustable on the base proper, which permits selection of a pulley size which, in connection with the Vari-Speed Motor Pulley, provides the speed variation required on the driven shaft.

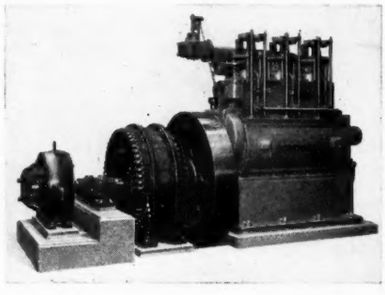
This unit is built in seven sizes ranging from less than one hp. to 7½ hp., and is applicable to many kinds of variable speed requirements of light horsepower but requiring a wide speed range.

New Vertical Gas Engines

A new line of vertical four-cycle gas engines, covering an unusually wide power range in a variety of cylinder combinations, recently has been announced by the Worthington Pump and Machinery Corporation, Harrison, N. J. These units, the outgrowth of 32 years of experience in the construction of internal combustion engines, are built with one to eight cylinders and 30 to 150 hp. per cylinder, thus meeting all power requirements from 30 to 1800 hp.

Many unique details of construction are incorporated in these engines, among them being: A mixing valve, common to all cylinders and adjustable through a single knurled handscrew, is employed on all but the largest units. Separate air and gas mixing valves—independently adjustable for each cylinder—are installed in each cylinder head of the largest engines. In all but the smallest units, air inlet and exhaust valves are carried in removable and interchangeable cages, the exhaust valve cages being water cooled; in the smaller engines, these valves (also interchangeable and adjustable) seat in the cylinder head and operate in removable bushings.

An attached reciprocating pump circu-

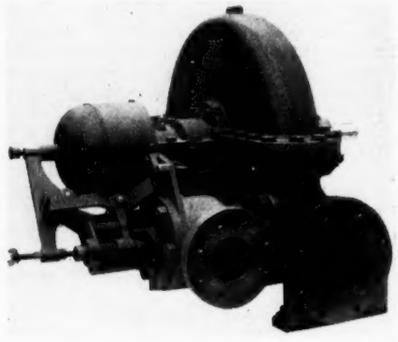


lates lubricating oil through a cast-in duct in the base with cast-in branches leading to the bottom of each main bearing. Through drilled passages in the crankshaft and connecting rods, the oil reaches the crank and wristpin bearings under pressure from the main bearings. Camshaft gear, governor and all other points requiring lubrication are supplied with oil under pressure from the flywheel end of the main oil duct. Two-point force feed lubrication of the cylinders is used on all but the smallest units.

Readily removable at right angles to the engine, the camshaft is driven from the flywheel end by spur gears with silent spiral teeth. A tight cover incloses the entire camshaft assembly, including its lubrication. All essential points (including the exhaust manifold) are cooled, the principal feature being that the flow of water in all jackets is so directed that high velocities result and there are no dead pockets. Both cylinder liners and heads are readily cleaned through large handholes, and unobstructed access to main and crank bearings is gained through large doors in the front and rear.

New Mechanical-Drive Turbine

A new mechanical-drive, noncondensing steam turbine for driving centrifugal pumps, fans, and other rotating equipment has been developed by the General Electric Company, Schenectady, New York. This turbine is suitable for driving equipment at speeds from 1200 to 4000 r.p.m. and is available up to 250 hp. under suitable steam conditions. The new turbine is a single-stage machine with two rows of revolving buckets. Simple in construction, it is an addition to the standard line of General Electric mechanical-drive turbines. The wheel casing is split horizontally to allow access to the internal parts and the steam

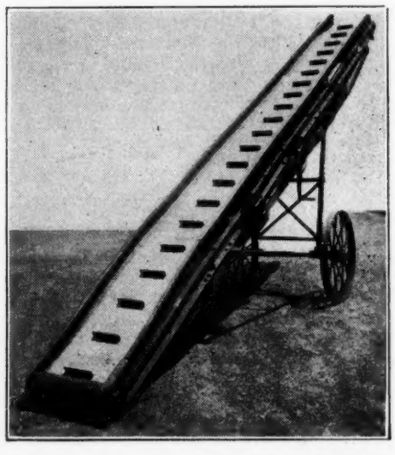


and exhaust pipes are connected to the lower half of the machine. A centrifugal governor, with weights pivoting on knife edges, operates with very little friction and provides proper speed regulation. An independent emergency governor is included.

Portable Belt Conveyor

The Link-Belt Company, Philadelphia, Pa., have placed on the market the new Link-Belt Portable Belt Conveyor. Fixed steel retaining sides extending the entire length of the conveyor prevent lumps from spilling over the sides of the belt at any point.

To eliminate a source of trouble common to portable belt conveyors of this



general type, the foot end has been improved to keep material away from the return run of the conveyor belt. The

foot end-plate has been made in a new arrangement which permits the removal of this foot end-plate when desired, minimizing labor in feeding, and serving to speed up loading.

Other features claimed and specifications are as follows: Length of conveyor is 21 ft. on centers. The belt is of the Link-Belt Service Brand, 18 or 24 in. wide. Idlers are of the all-metal troughing type with anti-friction roller bearings. Shaft bearings are all bronze-bushed. Head pulley is 9 in. in dia. and pulls without slipping. The foot pulley is bronze-bushed, runs loose on shaft and is adjustable from the outside to permit training of belt. The discharge height is regulated through spur geared hand crank by winding cable on or off drum. The conveyor has a heavy channel frame with full-length cover over return run of belt, and a simple underneath frame constructed of pipe. The wheels are wide-tread, large-diameter truck wheels fitted with roller bearings.

Magnetic Friction Clutches

The Dings Magnetic Separator Company, Milwaukee, Wis., has placed on the market the Dings Magnetic Clutch.

The Dings Type SD magnetic clutch consists essentially of three members—

the magnet body, the driven member, and the armature.

The magnet coil is mounted in the magnet body. Interposed between the magnet body and the armature is a double friction surface, supported by a spring plate attached to the driven member. When the coil is energized, the armature is attracted toward the magnet body, and exerts a pressure on both outside surfaces of the friction linings. The frictional force thus developed causes the driven member to accelerate smoothly and without jar.

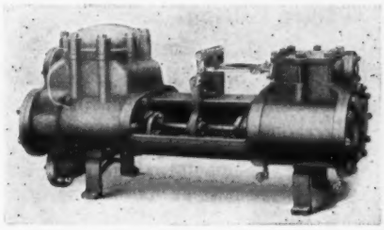
When the magnet coil is de-energized, the small spiral springs recessed in and between the magnet body and armature, force the armature away from the magnet body, whereas the spring plate causes an opening between the friction surface and the magnet body. It will be seen that there is at all times a running clearance between the magnet body, the friction surfaces and the armature.

Slip rings provide means for conducting the current through the coil.

New Line of Horizontal Steam Pumps

A new line of horizontal duplex steam pumps, especially designed and fitted for handling either water or chemical solutions, has recently been announced by the Worthington Pump and Machinery Corporation, Harrison, N. J. Built in three different types—valve plate, turret and pot valve—these units incorporate many new features which, it is claimed, represent the greatest advances in steam-pump construction in recent years. Foremost among these features is the adoption of stainless-steel drop-forged valve service on all models.

The valve plate type pumps have the discharge valves screwed into a common removable deck. These units are



of the submerged piston type with all suction and discharge valves above the cylinders. Valve service is of the disc type, and all pumps have the standard duplex steam end.

For transfer, tank, circulating, boiler feed and water supply service, units of this group are standard fitted and have forced-in liners and screwed stuffing boxes. For collecting condensate returns from heating systems and returning them to the boiler, these pumps are furnished complete with receiver and automatic float control. For handling brine, caustic solutions and special liquids, the units are all-iron fitted; for handling acids and acid solutions they are all-bronze throughout. This group covers capacities from 5 to 320 gal. per min. at pressures up to 250 lb. per sq. in.

Turret type pumps have the suction and discharge valve decks cast integral with the cylinders, are of the submerged piston design and have disc type valve service. Suction valves are accessible through handhole plates and discharge valves through the top cover. Stuffing boxes are of the bolted type with bolted glands.

Standard fitted (with forced-in cylinders) for all water service and all-iron fitted (with removable NiResist liners) for handling caustic solutions, turret type pumps are available for capacities of 150 to 840 gal. per min. for discharge pressures to 75 lb. per sq. in. and with capacities of 100 to 500 gal. per min. for pressures up to 200 lb. per sq. in.

Pumps of the pot valve pattern, all with submerged pistons, come in three types: For pressures up to 500 lb. per sq. in. with a capacity of 40 to 96 gal. per min. they have a special steam end with suction valves accessible through discharge valve seats. Stuffing box glands are bolted, piston rods are divided, cylinder liners are removable and valve service is of the poppet type.

For boiler feed service, capacities of 15 to 760 gal. per min. and discharge pressures to 300 lb. per sq. in., standard steam ends are utilized and liquid ends are of the outside end-packed-plunger pot valve pattern with bronze wing-type valve service.

For pressures up to 500 lb. per sq. in. and capacities of 140 to 1800 gal. per min., cylinders are fitted with bronze liners and liquid piston rods of stainless steel. Valve service, either disc or poppet type depending upon the pressure, is mounted in removable discharge valve decks. Stuffing boxes and glands are of the extra-deep bolted type.

Pressure Governor

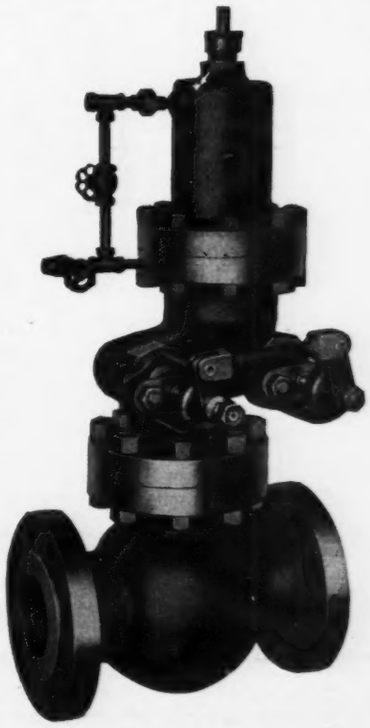
The Northern Equipment Company, Erie, Penna., manufacturers of Copes Feed Water Regulators, has developed a new Copes Governor which controls within close limits any excess pressure from 15 to 150 lb. It can be installed on simplex or duplex pumps, and on turbine- or motor-driven centrifugal pumps. It is suited for excess pressure service in boiler feeding; differential reducing valve service on motor-driven centrifugal pumps; and for constant-pressure service up to 150 lb.

The actuating element is a 4-ply brass sylphon bellows. This bellows is more rugged than that used in earlier Copes Governors. On test it has made 5 complete reversals per second for 215 days without sign of breakdown. It withstands unbalanced pressures as high as 400 lb. It is sensitive.

The sylphon bellows and the spring are in a separate chamber from the valve proper and hence can not come in contact with steam or water passing through the valve. In addition, the spring is chromium-plated, to eliminate any possibility of erosion from water introduced into the chamber through the pressure connections.

Stuffing box friction is reduced to a minimum by using the rotating valve stem employed in the control valve of the Copes Regulator since 1918.

The Copes Type SDS-2 Governor is furnished in all sizes up to 6 in. with straightway or angle style bodies, and



for all pressure standards from 250 lb. upward. All parts will withstand temperatures of 600 deg. fahr.

BOOKS for the Engineer

1—A.S.T.M. Refractories Manual

93 pages 6 x 9 Price 50 cents

This publication, issued by the American Society for Testing Materials, brings together in convenient form the several A. S. T. M. standard specifications, methods of testing and definitions pertaining to refractories. It also includes the latest revision of the Manual for Interpretation of Refractory Test Data.

2—A Handbook of English in Engineering Use

By A. C. Howell

308 Pages Price $2.50

Here is a real up-to-the-minute handbook that should be on the desk of every technical writer. Most engineers today have occasion to do considerable writing and for those who have some doubt as to their ability to express themselves clearly, accurately and in acceptable form, Professor Howell's book will be of very definite value. The author takes a very practical point with regard to the engineer's professional use of language. Chapters are devoted to word usage and idioms, sentence and paragraph structure, composition, punctuation and the mechanics of writing and grammar. Examples cover letters, reports and technical articles.

3—Industrial Gas Series—Combustion (Third Edition)

207 pages Price $2.00

Although a third edition, this book, prepared under the supervision of the Committee on "Combustion" of the Industrial Gas Section of the American Gas Association, has been so completely revised both with respect to content and treatment that it is in reality a new book.

The following chapter headings give a good idea of the scope covered by this book: Heat and Its Measurement; Gas Volume and Pressure; Chemistry of Combustion: Thermal Capacity; Heat Transfer; Combustion Data of Commercial Gases; Atmospheric Burners; Industrial Combustion Equipment; Temperature Control; Heat Salvage Methods; Gas Analysis; Fuel Comparisons.

4—Thermodynamics (Third Edition)

By J. E. Emswiler

347 pages Size 6 x 9 Price $3.00

The first edition of this book, published in 1921, was intended to present the subject matter with especial regard to the student's viewpoint. The ready acceptance of the text by teachers in engineering colleges all over the country testified to the success of the author's efforts.

In this new edition, the third, a considerable part of the text has been rewritten, much new material introduced, and several new problems added at the ends of the chapters.

The more important additions are as follows: two tables of the properties of ammonia; a fairly extensive treatment of the principle of the absorption system of refrigeration and, in this connection, an introduction to the idea of the use of solutions in power cycles; a summary of the rather numerous forms of the gas equations, and the solution of several problems exemplifying their use; an extension of the chapter on mixtures, consisting of articles on evaporation *vs.* boiling, on the approximate derivation of Carrier's equation, and on the theory of the wet-bulb thermometer, with some further illustrative examples; in the chapter on the air heat engine, articles dealing with the gas turbine, with throttling of the Otto cycle engine, and with supercharging; and finally, a rather extensive article on supersaturation of steam.

5—Finding and Stopping Waste in Modern Boiler Rooms

By H. B. Cochrane

808 pages Price $3.00

As a handbook on fuels, combustion, heat absorption, boilers and feed-water, this volume is eminently practical and useful. Every steam plant engineer should have a copy.

6—Mechanical Engineers' Handbook

By Lionel S. Marks

2265 pages Price $7.00

It is unnecessary to say a great deal about Marks' handbook. The third edition of this great reference book has been thoroughly revised in all parts, bringing it up to date in both practice and theory. Important new sections include vibration problems—refractories, high temperature carbonization of coal and gas making—low-temperature carbonization of coal—industrial combustion furnaces—electric industrial furnaces.

7—Industrial Furnace Technique

By A. Hermansen

293 pages Price $8.00

This book compiles a mass of valuable data which will be of great assistance to furnace builders as well as to those wishing to study this subject. As a whole this volume is the most complete treatise on furnace technique yet published. It merits the careful consideration of furnace designers and operators alike. The chapters on regenerators and recuperators are especially valuable as they contain reliable, constructive data for the proper design of such units which has never been published before.

8—Steam Tables and Mollier Diagram

By Joseph H. Keenan

Price $2.00

These new Steam Tables, extending to a pressure of 3500 lb. per sq. in. and a temperature of 1000 deg. fahr., were developed from the latest experimental data secured by investigators in laboratories of Europe and those of the United States. The Symbols used in this work are taken from the latest test prepared by the A.S.A. Sub-Committee for Heat and Thermodynamics. A large copy of the new Mollier Diagram (23″ x 34″) is also included.

IN-CE-CO PUBLISHING CORPORATION, 200 Madison Avenue, New York, N. Y.

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NAME_____ **Books Nos.**_____

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Postage prepaid in the United States on all orders accompanied by remittance or amounting to five dollars or over.

Boiler, Stoker and Pulverized Fuel Equipment Sales

As reported by equipment manufacturers to the Department of Commerce, Bureau of the Census.

Boiler Sales

Orders for 391 boilers were placed in August by 72 manufacturers

	Number	Square feet
August, 1932	391	271,238
August, 1931	792	553,711
January to August (inclusive, 1932)	2,258	2,225,992
Equivalent period, 1931	5,168	4,546,189
Total, 1931	7,508	6,327,262

NEW ORDERS, BY KIND, PLACED IN AUGUST, 1931-1932

Kind	August, 1931 Number	August, 1931 Square feet	August, 1932 Number	August, 1932 Square feet
Stationary:				
Water tube	53	196,304	33	98,214
Horizontal return tubular	44	57,712	22	28,031
Vertical fire tube	43	11,971	24	5,686
Locomotive, not railway	8	7,551	4	1,562
Steel heating	606	242,923	289	124,980
Oil country	1	1,264	5	3,850
Self contained portable	29	31,851	13	8,796
Miscellaneous	8	4,135	1	119
Total	792	553,711	391	271,238

Mechanical Stoker Sales

Orders for 197 stokers totaling 26,056 hp. were placed in August by 55 manufacturers

	Installed under Fire-tube boilers No.	Fire-tube boilers Horsepower	Water-tube boilers No.	Water-tube boilers Horsepower
August, 1932	159	13,229	38	12,827
August, 1931	261	32,773	72	22,103
January to August (inclusive, 1932)	608	72,797	267	107,106
Equivalent period, 1931	1,092	140,932	405	136,607
Total, 1931	1,889	252,571	574	187,507

Pulverized Fuel Equipment Sales

Orders for 6 pulverizers with a total capacity of 32,000 lb. per hr. were placed in August

STORAGE SYSTEM

	Pulverizers: Total Number	Pulverizers: No. for new boilers, furnaces and kilns	Pulverizers: No. for existing boilers	Pulverizers: Total capacity lb. coal per hour for contract	Water-tube Boilers: Number	Water-tube Boilers: Total sq. ft. steam generating surface	Water-tube Boilers: Total lb. steam per hour equivalent
August, 1932	..	..	..	....	..	....	.....
August, 1931	..	..	..	....	..	....	.....
January to August (inclusive, 1932)	..	..	..	....	..	....	.....
Equivalent period, 1931	7	6	1	220,000	3	114,577	1,671,000
Total, 1931	8	7	1	250,000	37	126,471	1,797,000

DIRECT FIRED OR UNIT SYSTEM

	Pulverizers: Total Number	Pulverizers: No. for new boilers, furnaces and kilns	Pulverizers: No. for existing boilers	Pulverizers: Total capacity lb. coal per hour for contract	Water-tube Boilers: Number	Water-tube Boilers: Total sq. ft. steam generating surface	Water-tube Boilers: Total lb. steam per hour equivalent
August, 1932	5	2	3	31,000	4	27,708	214,000
August, 1931	4	4	..	25,000	4	16,725	110,250
January to August (inclusive, 1932)	52	32	20	256,588	47	251,694	2,255,460
Equivalent period, 1931	61	45	16	418,710	47	380,605	4,159,395
Total, 1931	72	52	20	450,960	58	417,327	4,455,585
					Fire-tube Boilers		
August, 1932	1	1	..	1,000	1	1,310	5,900
August, 1931	4	1	3	4,250	4	7,307	43,600
January to August (inclusive, 1932)	13	2	11	13,300	13	20,310	114,650
Equivalent period, 1931	28	7	21	30,950	28	47,261	283,600
Total, 1931	35	1	24	39,300	37	59,761	347,100

ADVERTISERS

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Combustion

BOUND VOLUME NUMBER III

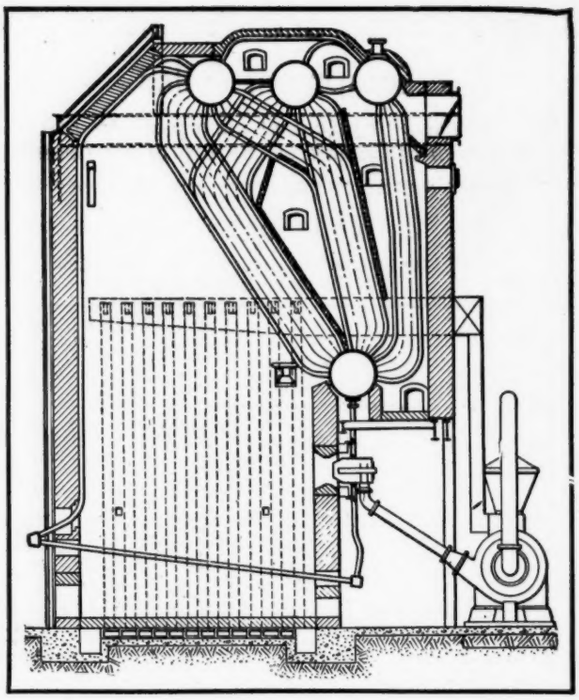
The July, 1932, issue of COMBUSTION, began the Fourth Volume of our magazine. We are prepared to supply bound copies of the Third Volume containing the twelve issues—July, 1931, through June, 1932. The binding is identical to that of volumes I and II, namely red library buckram with gold lettering on the back.

Price $6.00 each

NOTE—A limited supply of volumes One and Two is available. Copies will be furnished at $6.50 each until the supply of magazines is exhausted.

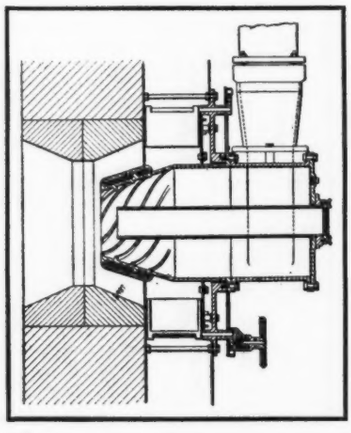
COMBUSTION MAGAZINE

200 Madison Avenue New York



Small unit comprised of C-E Multiple Circulation Boiler and Lopulco Direct-Fired Pulverized Fuel System.

Pulverized Fuel FIRING for Small Boilers



Section through Lopulco Type R Burner. This burner is built for a range of capacities including sizes suitable for firing small boilers such as that shown. It is simple in design and operation, and easily adjusted.

THE illustration above shows a simple, compact application of a Lopulco Direct-Fired Pulverized Fuel System. Such an arrangement is applicable to boilers of either the bent tube or horizontal tube type, in sizes from about 400 hp. up; in some instances, it may be advantageously applied to still smaller boilers.

Units of this type enable the small plant operator to obtain results comparable with those obtained in large power stations. The particular design shown will have an overall efficiency of approximately 80 per cent at 200 per cent of rating when using a fair grade of bituminous coal; considerably higher ratings can be carried with but little loss in efficiency.

In addition to assuring high efficiency over a wide range of ratings, such a unit offers the important advantages of easy and dependable operation, freedom from banking losses, and the ability to burn various coals, including the cheaper grades. The first cost is relatively low, and maintenance and operating costs are comparable with those obtained in large installations.

• • •

If you are interested in burning pulverized coal under small boilers, write us for further information.

COMBUSTION ENGINEERING CORPORATION

200 Madison Avenue, New York

PRODUCTS OF COMBUSTION ENGINEERING CORPORATION

BOILERS	**STOKERS**	Type E Underfeed Stoker	**PULVERIZED FUEL SYSTEMS**	C-E Water-Cooled Furnace
Combustion Steam Generator	Coxe Traveling Grate Stoker	Type E Stoker-Units (for small industrial and heating boilers)	Lopulco Storage System	C-E Air Preheaters
Heine Boilers	Green Chain Grate Stoker		Lopulco Direct Fired System	C-E Economizers
Ladd Boilers	C-E Multiple Retort Stoker		**MISCELLANEOUS**	C-E Ash Conveyors
Walsh-Weidner Boilers			Raymond Pulverizing Mills	C-E Ash Hopper

CATALOGS ON ANY OF THESE PRODUCTS WILL BE SENT UPON REQUEST